Garrison Cold Water Fishery Alternatives Assessment and Environmental Assessment with Finding of No Significant Impact

June 2005

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FINDING OF NO SIGNIFICANT IMPACT
Garrison Cold Water Fishery Alternatives Assessment
June 2005

I have reviewed and evaluated the documents concerning the proposal to provide a temporary method of maintaining suitable water quality in Lake Sakakawea that is supportive of cold water fisheries during a severe time of drought. The formulation of alternative means for accomplishing this goal has taken place in the form of a collaborative effort between the U.S. Army Corps of Engineers, North Dakota State Water Commission, North Dakota Game & Fish Department, North Dakota Department of Health, U.S. Fish and Wildlife Service Ecological Services Office, and the U.S. Fish and Wildlife Service Garrison Dam National Fish Hatchery.

The alternatives that I have reviewed fall within 3 basic categories: a) Physical Modifications, which included alternatives that alter the Garrison intake structure or the submerged intake channel within the lake; b) Flow Release Modifications, which included altering the daily release patterns to decrease the amount of coldwater taken during discharge while still discharging the same daily flow volume; and c) Lake Installation of equipment to alter the water quality by means such as mixing or oxygen injection.

The no action alternative was not selected because it would not provide a means to provide suitable water quality in Lake Sakakawea that is supportive of cold water fisheries.

The Preferred Alternative that was selected consists of a combination of modifying the Garrison daily flow cycle of releases and temporarily modifying the trash racks for intakes at penstocks two and three. The environmental consequences of the Preferred Alternative on the physical, biological, and cultural resources have been evaluated. Those factors that were influential in my review included: a) It is anticipated to protect cold water habitat and the fishery that relies on it; b) No long term significant adverse impacts to cultural or natural resources are anticipated to occur; c) Federal endangered and threatened species will either benefit or not be adversely impacted by the action; d) the action will not impact the Federal Fish Hatchery operations; e) the action is able to be implemented by the summer of 2005; f) the action provides operational flexibility at Garrison Dam; and g) All applicable Federal and state regulations will be met prior to contract award.

Based on the disclosure of the Preferred Alternative impacts contained within the attached Environmental Assessment, no significant impacts to the human environment are anticipated. The proposed project has been coordinated with the appropriate resource agencies, and there are no significant unresolved issues. Therefore, an Environmental Impact Statement is not needed prior to proceeding with the proposed Lake Sakakawea Coldwater Fishery Protection Project.

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Date

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Jeffrey A. Bedey
Colonel, U.S. Army
District Engineer

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ACKNOWLEDGEMENTS

This document was prepared in a collaborative effort with numerous federal and North Dakota state agency representatives. Without this cooperative effort, the rapid preparation of this document would not have been possible. Notable contributing agencies that served as the primary author of many sections within this document include the North Dakota State Water Commission, the North Dakota Game and Fish Department, the North Dakota Department of Health, and the U.S. Fish and Wildlife Service Garrison Dam National Fish Hatchery.

EXECUTIVE SUMMARY

Garrison Dam, which forms Lake Sakakawea, is located approximately 75 river miles north of Bismarck, North Dakota. The Garrison Project, one of six projects located on the main stem of the Missouri River, is a multipurpose project with authorized purposes including flood control, navigation, irrigation, hydropower, water supply, water quality, recreation, and fish and wildlife habitat. This document was prepared in a collaborative effort with numerous federal and North Dakota state agency representatives that served as the primary author of several sections.

The goal of the selected alternative is to provide a temporary method of maintaining suitable water quality in Lake Sakakawea that is supportive of cold water fisheries during a severe time of drought. Lake Sakakawea contains coldwater habitat that supports the Chinook salmon (*Oncorhynchus tshawytscha*) and rainbow smelt (*Osmerus mordax)*. Recreation at Lake Sakakawea is of great economic importance to the state of North Dakota, especially with respect to the fishery. Rainbow smelt are the primary forage species for most sport fishes in Lake Sakakawea including the highly sought salmon and walleye. Thus, reductions in the smelt population will have a ripple effect throughout the lake's entire recreational sport fishery. Unless emergency water quality management measures are implemented in 2005 to preserve the coldwater habitat in Lake Sakakawea, the recreational sport fishery in the lake will likely be adversely impacted.

Optimal cold water habitat in Lake Sakakawea is defined as water having a temperature ≤ 15°C and a dissolved oxygen concentration of ≥ 5 mg/l. The state of North Dakota has identified a late summer lake elevation of 1825 ft msl as the minimum level required to maintain enough coldwater habitat to sustain the coldwater fishery under current dam operations through the summer period. As indicated by data collected by the North Dakota Department of Game and Fish, the coldwater fishery in Lake Sakakawea was considerably affected by the substantial reduction in coldwater habitat which occurred in 2004.

Lake Sakakawea water levels continue to fall as drought conditions persist with a record low pool level of 1808.7 ft msl on 1 April 2005. As the pool level of Lake Sakakawea falls, the amount of cold water available at lower lake depths during summer thermal stratification is reduced. During summer thermal stratification the lake is also experiencing degradation of dissolved oxygen at lower lake depths as accumulated organic matter is decomposed. The situation is most critical later in the summer when the reduced volume of cold water combined with the degradation of dissolved oxygen in the deeper water of the lake act together to limit the coldwater habitat volume. As a result, it is probable that optimal coldwater habitat will not be maintainable in Lake Sakakawea through the end of the summer in 2005.

The reduction of coldwater habitat is exacerbated by the Garrison intake structure which tends to draw flow from the lower lake elevations. Alternatives that were formulated to minimize the loss of optimal cold water habitat volume included physical alterations to the dam intake structure or intake channel, modification of the daily flow release cycle, and lake installation of mixing or re-oxygenation equipment. No alternatives propose to modify the Garrison average daily flow release. The performed evaluation focused on short term alternatives. Long term alternatives that could not be implemented by early summer 2005 were not considered.

The main objective of the physical alteration alternatives is to conserve the lower level coldwater habitat volume by withdrawing upper level lake water. As a consequence of obtaining the objective, release water temperature and flow release rate are the primary factors that change from the current condition. In consideration of this, an impact assessment was performed on a number of elements that were most likely to be affected by such an action including the following: Garrison powerplant operations; Federal fish hatchery; downstream fishery; downstream power plants; downstream channel conditions, downstream water users; and Federally listed threatened and endangered species.

The selected alternative was chosen following a joint meeting held on 4 May, 2005 in Bismarck ND with attendees from numerous North Dakota state and federal agencies. The selected alternative consists of a combination of modifying the Garrison powerplant daily flow release cycle and physically modifying the trash rack for two intakes. Based on the findings of the Biological Assessment , the Corps finds there to be no significant impacts to the human environment.

This alternative was selected for several reasons including that implementation in a short time frame appears feasible, the selected alternative minimizes known impacts, the cost of implementing the selected alternative is reasonable, and the selected alternative is technically feasible. Trash rack barrier installation on only two units was selected as optimal to provide flow capacity for all low flow releases, limit impacts to the fish hatchery, limit impacts to the Garrison powerplant cooling, and limit temperature impacts to downstream water users. The maximum potential impact of the selected alternative on lake coldwater habitat volume is estimated to vary from 65% - 75% of the total daily release volume. For the daily release rate of 15,500 cfs, the maximum coldwater habitat volume that may be conserved is estimated as 20,000 to 23,000 acre-ft per day. However, implementation of the selected alternative does not directly address dissolved oxygen levels which may reduce the conserved coldwater habitat volume.

Implementation of the modification of the daily flow cycle is the responsibility of the U.S. Army Corps of Engineers, Northwestern Division, Missouri River Basin Reservoir Control Center (RCC). This alternative will not require any construction. RCC has coordinated this option with Western Area Power Administration (WAPA) and informed Omaha District regarding implementation. Initial implementation of the modified daily flow cycle occurred in May, 2005, prior to the least tern and piping plover nesting season. Small adjustments to the daily release pattern may occur during the beginning of June.

The trash rack modification requires removal of the existing trash racks, attachment of the plywood barrier from elevation 1672 to 1720 ft msl to block the lower half of the intake, and installation of the modified trash racks. The current schedule consists of completing unit 3 modifications by 2 July 2005 and unit 2 modifications by 16 July 2005. Implementation of the trash rack modification may encounter unforeseen difficulties during construction that prevent successful installation of the barrier on one or both intakes. Actual installation time could vary significantly. Total material and construction costs are estimated as between $40,000 and $50,000 for the modification of two intakes. Additional notes regarding trash rack modification are as follows:

- Trash rack barrier installation is not watertight. Some leakage will occur. In addition, a small slot is required on the bottom barrier to limit silt accumulation during operation.
- Trash rack barrier installation is temporary and will be removed in the fall following lake turnover. At this time, cold water habitat is no longer impacted by the trash rack barrier.
- If obstacles are encountered during the trash rack barrier installation process it may not be possible to complete installation. Rather than compromise Garrison project integrity, the operation process will be halted.
- The intake modification was selected for units 2 and 3 with unit 1 as an alternate. Units 4 and 5, which supply cold water to the fish hatchery, were not considered.
- Computations determined that a destructive vibration force could occur through the trash rack struts at high velocity. Thus, if the bottom trash rack section is not successfully removed, operation with barriers installed on the upper sections only is not possible.

1. INTRODUCTION

The Garrison Project is located on the Missouri River approximately 75 river miles north of Bismarck, North Dakota in McLean and Mercer Counties. The Garrison Dam-Lake Sakakawea Project is one of six projects located on the main stem of the Missouri River. The project is part of a hydraulically and electrically integrated system which is regulated to obtain the optimum fulfillment of the multipurpose benefits for which the main stem reservoirs were authorized and constructed. The Missouri River Main Stem Reservoir System is operated under guidelines described in the reservoir regulation manual "Master Manual" (RCC, 2004). The "Master Manual" also describes in detail operation for the flood control, multipurpose, and emergency regulation procedures, in accordance with authorized project purposes. As one of the multipurpose uses, the Garrison Project is a great recreational resource, and is a major visitor destination in North Dakota.

1.1 PURPOSE

The purpose of the action being pursued is to provide a temporary method of maintaining suitable water quality in Lake Sakakawea that is supportive of cold water fisheries during a severe time of drought. The purpose of this document is to describe the cold water fishery problem at Lake Sakakawea, outline identified alternative actions, evaluate identified impacts and constraints that apply to alternative implementation, and provide a recommended alternative. The performed evaluation focused on short term alternatives that could be implemented within the early summer of 2005.

1.2 NEED

The sport fishery in Lake Sakakawea is of great recreational and economic importance to the State of North Dakota. Based on data supplied by the North Dakota State Water Commission, the economic loss that is projected to occur from 2004 to 2011 in Lake Sakakawea due to the loss of angling days is over $90 million (Shultz, 2004). The lake's current fishery can be described as a "two-story fishery" composed of fish from warm water species to cold water species. Cool and warm water species present in the lake that are recreationally important include walleye (*Sander vitreus*), sauger (*Sander canadensis)*, northern pike (*Esox lucius)*, smallmouth bass (*Micropterus dolomieu)*, catfish (*Ictalurus spp.*), and yellow perch (*Perca flavescens)*. The Chinook salmon (*Oncorhynchus tshawytscha*) is a coldwater species of recreational importance that is maintained in the lake through regular stocking. The primary forage fish utilized by both warm and cold water sport fishes in the lake is the rainbow smelt (*Osmerus mordax)* – a coldwater species. The continued pool level drawdown of Lake Sakakawea, due to the ongoing drought conditions in the interior western United States, has reduced the amount of cold water habitat in Lake Sakakawea to critical levels. If the current sport fishery in Lake Sakakawea is to be maintained through the ongoing drought, measures to protect the cold water habitat in the lake need to be implemented.

1.3 PROBLEM IDENTIFICATION

The state of North Dakota has identified a late summer lake elevation of 1825 ft msl as the minimum level to maintain enough coldwater habitat to sustain the coldwater fishery, and since 2002, the rainbow smelt have been stressed (see Attachment 2) . The Garrison pool elevation has reached a record low level with an elevation of 1808.7 ft msl on 1 April 2005. The previous low elevation of 1815.0 ft msl was set in May 1991. Pool levels in Lake Sakakawea will continue to drop if the ongoing drought conditions persist in 2005 as forecasted. As a result, it will become increasing more probable that optimal coldwater habitat will not be maintainable in Lake Sakakawea through the end of the summer. The reduction of coldwater habitat is exacerbated by the Garrison intake structure which tends to draw flow from the lower lake elevations.

The pool level of Lake Sakakawea is reaching a point where the reduced hypolimnetic volume of cold water, in concert with the degradation of dissolved oxygen in the deeper water of the lake, is limiting the occurrence of optimal cold water habitat. The situation is most critical later in the summer when dissolved oxygen levels in the hypolimnion of the lake reach their lowest point. The loss of optimal cold water habitat in Lake Sakakawea will reduce the lake's ability to support Chinook salmon and rainbow smelt. Since the rainbow smelt is the primary forage species for most sport fishes in Lake Sakakawea, reductions in the smelt population will have a ripple effect throughout the lake's entire recreational sport fishery. Unless emergency water quality management measures are implemented in 2005 to preserve the coldwater habitat in Lake Sakakawea, the recreational sport fishery in the lake will likely be adversely impacted.

Lake elevations are dependent upon Missouri River runoff and mainstem system operation. Frequent studies are performed by the U.S. Army Corps of Engineers, Northwestern Division, Missouri River Basin Reservoir Control Center (RCC). RCC prepares an annual operating plan that includes forecasted system pool elevations for normal, lower decile, and upper decile runoff scenarios (RCC, 2005). Using the RCC study performed May 2, 2005, the anticipated Lake Sakakawea normal daily release rate through the summer of 2005 is 15,500 cfs. Forecasted Garrison pool elevations and flow releases for the summer of 2005 are stated in Table 1 as follows:

Table 1
Garrison Forecasted Pool Elevations (ft) / Average Monthly Discharge (cfs) (1)

Runoff Scenario	31 May	30 Jun	31 Jul	31 Aug	30 Sep
Normal	1805.6 16.5	1806.3 15.5	1804.2 15.5	1804.3 15.5	1804.6 14.5
Lower	1804.6 16.5	1803.7 15.0	1801.4 14.5	1801.0 14.5	1801.0 12.3
Upper	1807.4 16.5	1811.7 17.0	1810.1 17.0	1810.1 17.0	1810.7 14.0

(1) Forecast elevation prepared by the RCC as described in the Annual Operating Plan, (USACE, 2004), based on 2 May 2005 projections. Note that these values will be updated monthly to reflect actual runoff conditions and pool elevations.

1.4 RANGE OF ALTERNATIVES EVALUATED

Alternatives were formulated to minimize the loss of optimal cold water habitat volume within Lake Sakakawea during the summer months of 2005. Alternative formulation considered that reservoir releases must follow the RCC regulating plan and current Master Manual (RCC, 2004). Long term alternatives that could not be implemented by early summer were identified but not considered for further action with this study. While long-term water quality management planning is being pursued at the Garrison Project and Lake Sakakawea implementation of such a solution would not address the immediate need for the summer of 2005. Alternatives that were evaluated may be grouped in the categories of physical modification, flow release modification, and lake installation to impact water quality.

Physical Modification: These types of alternatives refer to physically altering the Garrison intake structure or the submerged intake channel.

Flow Release Modification: While the flow release must follow the system regulation plan developed to follow the Master Manual, it may be possible to alter the daily release pattern while still discharging the same daily flow volume.

Lake Installation: These alternatives use equipment installed in Lake Sakakawea to alter the water quality by means such as mixing or oxygen injection.

Long Term Alternatives: These are alternatives that were identified but not considered since implementation during the summer of 2005 was not feasible.

The identified alternatives are summarized in Table 2.

Table 2. Identified Alternatives	
Physical Modification	
	Intake Trash Rack Modification
	Intake Channel Curtain
	Intake Channel Permanent Barrier
Modify Flow Release	
	Reduce Minimum Flow Release
	Modify Daily Flow Cycle
Lake Installation	
	Lake Mixing
	Re-Oxygenation
Long Term Alternatives	

1.5 POTENTIAL IMPACTS

Via agency scoping, (see attachment 10)a number of potential impacts have been identified for the various alternatives. Impacts are related to the Garrison power plant, downstream water users, and downstream channel water quality. Potential impacts and the primary cause/effect of the impacts are listed in Table 3.

Table 3
Potential Impacts of Alternative Implementation

Potential Impacted Element	Primary Cause\Effect of Impact [1]
Garrison Power Plant Cooling Water	Increasing temperature of cooling water lowers generating capacity and/or efficiency.
Garrison Power Plant Efficiency Losses	Physical modification to the intake causes additional head loss and reduction of plant capacity.
Downstream Coldwater Fish Hatchery	Increasing temperature of water in penstocks 4 and 5 impacts water quality to the hatchery and the ability to raise cold water species.
Downstream Tailwater Coldwater Fishery and River Fishery	Increasing temperature of release water raises downstream Missouri River temperature and impacts species environment.
Downstream Power Plants Cooling Water	Temperature raise of release water raises downstream Missouri River temperature and impacts power plant cooling capability and generation efficiency.
Downstream Channel and Water Users	Release flow variation affects water levels and river environment.
Downstream Municipal Water Users	Release flow variation affects water levels and river environment.
Threatened and Endangered Species	Alternative implementation may impact the species environment.

1 Degree of impact is variable and will depend upon alternative that is implemented as well as other factors such as tributary inflow, average daily temperature, and etc.

2. AFFECTED ENVIRONMENT

The primary affected environment includes Lake Sakakawea, Garrison Dam and supporting facilities, and the Missouri River downstream of the reservoir. The affected environment has been evaluated in numerous studies dating over 70 years to pre-dam construction times. Recent pertinent studies that evaluate the affected environment include the *U.S. Fish and Wildlife Service Amendment to the 2000 Biological Opinion* (USFWS, 2003), the *Missouri River Master Water Control Manual, Review and Update FEIS* (RCC, 2004), and the recently updated *Missouri River Mainstem Reservoir System, Master Water Control Manual* (RCC, 2004).

A summary of Garrison Dam History and Operation and Maintenance features are contained within the *Operation and Maintenance Manual, Missouri River, Garrison Dam, Lake Sakakawea Project, North Dakota, Volume I-IV, Omaha District, 1982*. Garrison Dam and Reservoir is a multiple purpose project consisting of a rolled earth filled dam with a sheet pile cut-off, a hydro-electric generating plant and a reservoir with capacity of 24,500,000 acre feet for flood control, conservation, navigation, power development, irrigation and other uses. The earth dam is 12,000 feet long, 210 feet in height and contains 66,500,000 cubic yards of earth fill. The concrete spillway in the east bank is a gated ogee crest structure controlled by 28 tainter gates and has a discharge capacity of 827,000 cfs. The outlet works and hydro-electric generating plant are located in the west abutment. The outlet works consists of an intake structure, 5 power penstocks, 3 flood control tunnels, and a stilling basin. The five hydraulic turbine driven generating units and operating and maintenance facilities are housed in the powerhouse. North Dakota State Highway 200 crosses the Missouri River over Garrison Dam. Construction of the Garrison project was initiated in 1946. Dam closure was made in 1953, with power plant operation on line in 1956.

The outlet works and powerplant that are located in the west abutment were connected to the mainstem Missouri River with an intake channel during dam construction to allow river diversion. The constructed intake channel has an invert elevation of 1670 msl with a bottom width of about 500 feet at the intake structure that reduces down to a width of about 350 feet after about 1500 feet upstream of the intake. The intake channel top of slope is about elevation 1750 msl near the intake structure. As the intake channel approaches the Missouri River channel, the top elevation reduces down to about 1720 feet msl. The total intake channel length with top of cut elevations above 1700 feet msl is over 8,000 feet. Note that these dimensions are approximate based on construction drawings. A hydrographic survey is required to determine current channel dimensions.

2.1 GARRISON POWER FACILITIES AND RELEASES.

Since 1956, outflows from Garrison have generally been through the power facilities that have a maximum capacity of about 38,000 cfs with a generating capacity of about 572.5 MW. The average flow release is about 22,800 cfs and the powerplant produces an average of 2.5 million MWh of energy annually. (RCC, 2004, page F-2). For summer 2005, the average daily flow release is 15,500 cfs. Refer to Table 1 for the updated 2005 Garrison pool and reservoir release forecast.

2.1.1 Garrison Powerplant Cooling Water

The Garrison Powerhouse uses water from the raw water loop in the plant for cooling water operations and water supply needs. The raw water loop is a 12” loop header which extends around the periphery of the turbine floor with valved connections to the following equipment and systems: 1) generator and thrust bearing cooling water systems; 2) the turbine shaft packing gland and turbine runner wearing ring lubrication systems; 3) the unit transformer heat exchangers; 4) bearing lubrication to the station service and unwatering pumps; and 5) a 12” header in the station water treatment plant having connections to the Riverdale water supply system, the station fire and general service water system, the powerplant treated water system, the unit transformer fire protection system, the cooling coil to the station service switchgear room, and the powerplant air conditioning systems. The water is supplied to the loop header through 12" taps on each of the scroll cases and penstocks.

The water supply tap from each scroll case connects into the 12" supply line from the loop header to the respective unit. In an emergency or if the tap from the scroll case of one unit is closed, there is adequate water from the loop header to be used as backup cooling water for one unit.

2.1.2 Garrison Powerplant Efficiency

Power generated by the Garrison hydroelectric plant is dependent upon many factors including lake level and the head loss that occurs as flow is conveyed through the intake structure and the penstock to the turbine. A modification that alters the flow path and causes additional head loss will cause a reduction in power generation that may be viewed as an efficiency loss. As powerplant efficiency declines, less power is generated for the same pool level.

2.1.3 Peak Generation

The Garrison power plant is primarily a semi-peaking plant. Operation includes daily peaking as described as follows in the Annual Operating Plan (RCC, 2004, pg. 19):

> *Daily average releases from Garrison will be much less than full powerplant capacity during the tern and plover nesting season under all runoff scenarios. Monthly average releases will decline 500 to 1,000 cfs during the summer nesting season. Hourly peaking will be limited to no more than 30,000 cfs for six hours if the daily average release is lower than 28,000 cfs. This will limit peak stages below the project for nesting birds.*

Referring to 2003 and 2004 summer operations, daily flow releases cycled from a low of about 8,000 cfs to a maximum of about 28,000 cfs. Daily flow cycles are in response to peak power demands and also serve to maintain nesting elevations for Least Tern (*Sterna antillarum*) and Piping Plovers (*Charadrius melodus*). During the nesting season of the endangered interior least tern and the threatened piping plover, care must be taken to avoid impacts to nesting areas. These two bird species are listed as threatened and endangered under the Endangered Species Act (ESA) and are protected under that Act. Maintaining the nests at a high elevation allows operation flexibility and is an annual occurrence as described in the Annual Operating Plan (RCC, 2005, pg. 19).

2.1.4 Garrison Project Summary.

Plate 1 illustrates Garrison dam and the intake channel. Plate 2 illustrates the existing intake structure. Pertinent data concerning Garrison Dam and flow release capability is summarized in Table 4.

Table 4.
Garrison Dam Pertinent Data

Location	Near Garrison, ND, at Missouri River Mile 1389.9	
Base of Flood Control Pool and Area	1837.5 ft	307,000 acres
Minimum Operating Pool	1775 ft	129,000 acres
Flood Control and Multiple Use	1775 – 1837.5 ft	13,219,000 acre-feet
Power Conduits	5 Penstocks, Intake Elev of 1672.0 ft	
Power Discharge Capacity	38,000 cfs at 150 ft head	

2.2 WATER QUALITY AND HABITAT

A preliminary study of Lake Sakakawea water quality was completed by the Omaha District Corps of Engineers in October 2004 (Omaha District, 2004). This document is included for reference material as Attachment 1.

2.2.1 Lake Sakakawea

2.2.1.1 Thermal Regime

Lake Sakakawea exhibits a thermal regime typical of a temperate-zone dimictic lake with an annual spring and fall mixing period.

During the winter months ice formation prevents wind mixing of Lake Sakakawea, and an inverse temperature stratification forms under the ice. The bottom water will stay near maximum density at 4°C, but the surface waters become colder and less dense and offer resistance to mixing. As a result, an inverse thermal stratification occurs with 0°C water at the surface and 4°C water near the bottom.

As the ice cover on Lake Sakakawea deteriorates in the spring, the surface water, which is near 0°C, begins to warm and approach the temperature of the bottom water. Since the density of the surface water increases as it approaches 4°C, this surface water sinks and mixes with the water below it. During this period, there is relatively little thermally induced resistance to mixing because of the small density differences, and the lake becomes uniform near 4°C. This period of uniform temperature when the entire water column is mixing is referred to a spring turnover. Spring turnover typically occurs in Lake Sakakawea after "ice out" in late April and early May. The extent of spring turnover is primarily dependent on inflow density, wind mixing, and solar insolation. Solar insolation warms the surface water and thereby establishes a density gradient between the surface and underlying water. However, wind energy introduced across the water surface stirs the water column and distributes this heat into the water column, resulting in an increase in the temperature of the entire water column. As solar insolation intensifies, wind energy no longer can overcome the density gradient between the surface and the bottom and completely mix the water column, which leads to thermal stratification of Lake Sakakawea.

During the summer, solar insolation has its highest intensity and Lake Sakakawea becomes stratified into three vertical zones: 1) epilimnion, 2) metalimnion, and 3) hypolimnion. The epilimnion is the upper zone that consists of the less dense, warmer water in the lake. Its thickness is determined by turbulent kinetic energy inputs (e.g., wind, convection, etc.), and a relatively uniform temperature distribution throughout this zone is maintained. The metalimnion is the middle zone that represents the transition from warm surface water to colder bottom water. There is a distinct temperature gradient through the metalimnion. The hypolimnion is the bottom zone of the denser, colder water that is relatively quiescent. Water temperatures in the hypolimnion of Lake Sakakawea during the summer typically remain below 15°C, while water temperatures in the epilimnion commonly exceed 20°C. The metalimnetic zone in Lake Sakakawea generally occurs between 20 and 30 meters (66 to 98 feet) of depth. Since the depth of the metalimnion remains relatively constant with pool level, the elevation to the top of the hypolimnion decreases as pool levels drop. This results in less hypolimnetic volume occurring in the lake as the pool levels decrease. The summertime thermal stratification of Lake Sakakawea allows for the maintenance of the lake's "two story fishery". Under stratified conditions cool water fish species can move throughout the lake, but will be most prevalent in the warmer epilimnion. Because of their intolerance to warm temperatures, cold water fish species are generally restricted to the colder hypolimnetic zone.

As solar insolation decreases during late summer and early fall and the air and inflow temperatures cool, heat losses from Lake Sakakawea exceed heat inputs, and the water surface temperatures decrease. This results in 1) the surface water becoming denser and mixing with the deeper water through wind and convection currents, and 2) a reduction of the density difference between the mixed layer and hypolimnion. This situation results in a deepening of the mixed layer and erosion of the metalimnion and hypolimnion until the mixed layer reaches the lake bottom and the water column is a uniform temperature. This period of complete mixing and uniform temperature in the water column is referred to as fall turnover. Fall turnover typically occurs in Lake Sakakawea in late September to early October.

Monitoring data collected by the Omaha District in 2003 and 2004 indicated that Lake Sakakawea, near the dam, experience fall turnover on September 25th and October 1st respectively. The water temperature of Lake Sakakawea at fall turnover in 2003 and 2004 was about 16-17°C.

2.2.1.2 Dissolved Oxygen

Oxygen is a fundamental chemical constituent of a water body that is essential to the survival of aquatic organisms. Oxygen is produced by aquatic plants (plankton and macrophytes) and is consumed by aquatic plants, other biological organisms, and chemical oxidations. The distribution of dissolved oxygen (DO) in reservoirs is a result of dynamic transfer processes from the atmospheric and photosynthetic sources to consumptive uses. Under summer thermal stratified conditions, DO levels in the epilimnion tend to be near saturation due to wind driven mixing and convection within the epilimnion, while dissolved oxygen levels in the quiescent hypolimnion can be reduced due to decomposition of organic matter and chemical oxidations. Lake Sakakawea exhibits a clinograde dissolved oxygen distribution -- the hypolimnetic dissolved oxygen concentration progressively decreases during summer stratification.

In reservoirs such as Lake Sakakawea, the DO demand may be divided into two separate but highly interactive fractions: sediment oxygen demand (SOD) and water column demand. The SOD is typically highest in the upstream area of the reservoir just below the headwaters. This area is relatively shallow but can stratify. The loading and sedimentation of organic matter in this transition area is high and during stratification the hypolimnetic DO to satisfy this demand can be depleted. If anoxic conditions develop, they generally do so in this area of the reservoir. They are generally initiated at the sediment/water interface and gradually diffuse into the overlying water column and downstream toward the dam. Anoxic conditions may also develop in a deep pocket near the dam due to decomposition of autochthonous organic matter settling to the bottom. This anoxic pocket, in addition to expanding vertically into the water column, may also move upstream and eventually meet the anoxic zone moving downstream. In bottom-release reservoirs such as Lake Sakakawea, the anoxic water that develops in the upstream area of the reservoir can be drawn toward the dam by a density current along the bottom. The movement of water from the upstream area of a reservoir to the dam can also be accelerated as the reservoir pool level drops and the retention time of the reservoir decreases. A water column oxygen demand can occur when density interflows transport oxygen-demanding material into the epilimnion and metalimnion and this material settles through the water column.

Hypolimnetic DO depletion can become limiting to aquatic life in shallow, stratified reservoirs since there is a smaller hypolimnetic volume of oxygen to satisfy oxygen demands. As mention in Section 2.2.1.1, as the pool level in Lake Sakakawea drops, the hypolimnetic volume also decreases and hypolimnetic dissolved oxygen depletion becomes a greater concern. Based on monitoring conducted by the Omaha District in 2003 and 2004, significant hypolimnetic oxygen depletion occurred in Lake Sakakawea during summer stratification. Hypolimnetic DO concentrations less than 5 mg/l were monitored during the early summer in the middle upper reaches of Lakes Sakakawea (i.e., Independence Point to Indian Hills), and during the late summer in the lower reaches of the lake near the dam.

2.2.1.3 Optimal Cold Water Habitat

Optimal cold water habitat in Lake Sakakawea is defined as water having a temperature ≤ 15°C and a dissolved oxygen concentration of ≥ 5 mg/l. The State of North Dakota believes these water quality conditions are needed to optimally support the cold water fishery in Lake Sakakawea. The occurrence of optimal cold water habitat in Lake Sakakawea depends on several factors; however, those seemingly of most importance include: time of year (i.e., season), weather conditions, and pool level.

Seasonal Factor. The occurrence of optimal cold water habitat (i.e., water temperature ≤ 15°C and DO concentration ≥ 5 mg/l) in Lake Sakakawea varies seasonally. Seasonal variation is discussed in the following paragraphs:

Winter. During the winter under ice cover, water temperatures throughout the lake are less than 15°C. As the winter progresses, the oxygen demand of lake-bottom material can lower dissolved oxygen levels below 5 mg/l near the lake bottom. The occurrence of optimal cold water habitat will decrease through the winter as dissolved oxygen degradation occurs near the lake bottom; however, it is not considered a significant concern since the entire volume of the lake is less than 15°C.

Spring. At spring turnover, water temperatures and DO concentrations are such that the entire volume of Lake Sakakawea is supportive of optimal cold water habitat.

Summer. Optimal cold water habitat in Lake Sakakawea decreases as the lake becomes thermally stratified during the summer. As the epilimnion becomes established and warms, water temperatures in the epilimnion will exceed 15°C. Maximum stratification of Lake Sakakawea (i.e., maximum epilimnetic water temperatures) generally occurs in mid to late July. Generally by early August, Lake Sakakawea begins to cool and the mixed epilimnetic layer begins to mix with the underlying metalimnion and hypolimnion. This results in a decreasing hypolimnetic volume, thus decreasing the volume of optimal cold water habitat. As the optimal cold water habitat in Lake Sakakawea decreases throughout the late summer due to the reduction of the hypolimnion from above, optimal cold water habitat is also being reduced from the bottom due to depletion of DO. Hypothetically, a point could be reached in late summer where the lowering depth of the upper hypolimnion boundary intersects the rising depth of low DO water. If this "crossover" situation were to occur, there could be no optimal cold water habitat present in Lake Sakakawea for a significant amount of time during the summer.

Fall. The described reduction in cold water habitat continues until fall turnover when Lake Sakakawea completely mixes to the bottom. During fall turnover there appears to be a short period of time when no optimal cold water habitat occurs in Lake Sakakawea because water temperatures throughout the lake are slightly above 15°C.

Weather Factor. Weather conditions can markedly affect the degree of summer thermal stratification that occurs in Lake Sakakawea. This situation was witnessed in 2004. The late spring and early summer of 2004 were unusually cool and overcast in North Dakota. This resulted in Lake Sakakawea gaining less heat than normal through this period. Based on monitoring data collected by the Omaha District during 2004, Lake Sakakawea only exhibited weak thermal stratification, and epilimnetic water temperatures during the mid to late summer generally remained below 18°C.

Pool Level Factor. The pool level of Lake Sakakawea has a direct effect on optimal cold water habitat in the lake. As the pool level of Lake Sakakawea decreases so does the hypolimnetic volume of the lake. Reducing the volume of the hypolimnion reduces the amount of cold water present and the occurrence of optimal cold water habitat in the lake. A reduced hypolimnetic volume also potentially exacerbates DO depletion which can erode away optimal cold water habitat. In most cases, there will be more optimal cold water habitat present in the lake during all seasons with higher pool levels. A possible exception could be late summer during thermal stratification -- this exception would only occur if "crossover" of the eroding hypolimnion boundary and low DO water occurred at both a higher and lower pool level.

Optimal Volume. The amount of optimal cold water habitat present in Lake Sakakawea in 2003 and 2004 was estimated by the Omaha District. This estimate is based on monitoring data collected by the Omaha District and utilization of the lake volume and lake elevation relationships defined by Houston

Engineering in its Lake Sakakawea database for the report "Lake Sakakawea Analysis of Cold Water Habitat". Plate 3 shows a plot of total lake volume and optimal cold water habitat estimated in Lake Sakakawea during 2003 and 2004. The plot of optimal cold water habitat shows a decrease in the volume of estimated habitat through the June to September period in both years. Based on the rate of decrease in the estimated habitat, the plotted data can be separated into three periods: 1) June to mid July, 2) mid July to late August, and 3) late August to late September. During the June to mid-July period a rapid decline in the optimal cold water habitat in Lake Sakakawea occurred (Plate 3). This rapid decline is primarily attributed to the development of thermal stratification and the warming of the epilimnion. During the mid July to mid August period the rate of decline in the optimal cold water habitat decreases (Plate 3). The loss of optimal cold water habitat during this period is attributed to discharge of hypolimnetic water through the dam, the erosion of the hypolimnion due to lake cooling, and the depletion of DO in the hypolimnion. During the final period, the rate of loss of optimal cold water habitat exhibits a decrease from the previous period (Plate 3). The reduced rate of loss of optimal cold water habitat during this period is attributed to the reduction in the volume of water discharged through the dam that met the temperature and DO criteria for optimal cold water habitat. It appears that about 100,000 acre-feet of optimal cold water habitat remained in Lake Sakakawea in 2004 just prior to fall turnover. For comparison purposes, the 2005 average daily discharge rate of 15,500 cfs (Table 1) corresponds to a daily volume release of 31,000 acre-feet.

2.2.1.4 Lake Sakakawea Lacustrine Habitat and Associated Biota

The overall fishery of Lake Sakakawea is represented by 58 documented fish species (Attachment 5). Both Lake Sakakawea and the Garrison Reach have a mix of warm water to coldwater species; however, many of the native large river species (e.g. pallid sturgeon, sicklefin chub, sturgeon chub and flathead chub) are very rare. Refer to Attachment 3 for additional information.

Lake Sakakawea is a managed recreational fishery, managed primarily for walleye, sauger (cool water), and Chinook salmon (cold water). The lake also supports the introduced rainbow smelt (cold water), which provide the main forage base for the reservoir sport fishery. The health of the walleye and salmon populations rely heavily on the reproduction and survival of rainbow smelt. The rainbow smelt were stocked by North Dakota Game and Fish biologists in 1971 to serve as a forage base, and became established in Oahe shortly after via passage through Garrison Dam (Morrone 1996). Subsequent establishment in reservoirs further downstream has not occurred, as those lakes do not thermally stratify and support a cold water zone (Morrone 1996).

Lake Sakakawea is a large reservoir with two main habitat types - littoral and open water habitat. Littoral habitat, or shoreline habitat, is the area of shallow water that surrounds the lake. Because of the shallow depths, emergent and rooted aquatic plants may grow and provide important habitat to many species of fish and invertebrates. With approximately 1600 miles of shoreline on Lake Sakakawea, which is greater than the total amount of California oceanfront shoreline, it is clearly an important habitat type. Depending on fluctuations in the reservoir, the amount of vegetation varies, with the upstream delta area having the most prevalent habitat of this type. When lake levels are receeding, large, non-vegetated, sandy expanses of shoreline are exposed, providing a habitat type that is suitable for the federally listed piping plover and least tern to nest and feed. When water is rising, established emergent and riparian vegetation becomes inundated, providing greater habitat for fish, while nesting habitat for shore birds declines.

The open water habitat consists of that part of the lake in which the shore or the bottom have a lessened influence. This area is seasonally stratified from top to bottom by temperature and oxygen gradients (see water quality section). These layers of differing temperature and oxygen can be very critical in the types of species that can survive in the lake. The lower, hypolimnetic zone has the coldest water, which supports cold water conditions necessary for rainbow smelt survival, the main food organism that supports the recreational fishery in the lake. The cold water also supports the popular salmon fishery. Rainbow smelt are the primary forage for all major sport fish in Lake Sakakawea. Because of this, reductions in rainbow smelt have impacts to the sport fish populations. Since 2001, the rainbow smelt population has declined by 80% in number and 93% in biomass (Figure 1). These declines are due to the loss of coldwater habitat during the stratification period (June through September) and poor reproduction due to the loss of spawning habitat and declining water levels during and shortly after the spawning period.

Rainbow smelt deposit approximately 85% of their eggs in water less than 9 inches deep in Lake Sakakawea. Water levels must be rising in the spring to ensure successful reproduction. The major spawning run for smelt was from April 21 to 26 in 2005 and the lake elevation has declined 1.4 ft since the spawning period. This will result in very poor reproduction for smelt in 2005.

The lack of reproduction increases the importance of maintaining the coldwater habitat in Lake Sakakawea in 2005. A total loss of coldwater habitat could severely impact the adult population and if there are no young-of-the-year, then the recovery time for the population would be significantly longer. Figure 1 illustrates the smelt numbers and biomass since 1999.

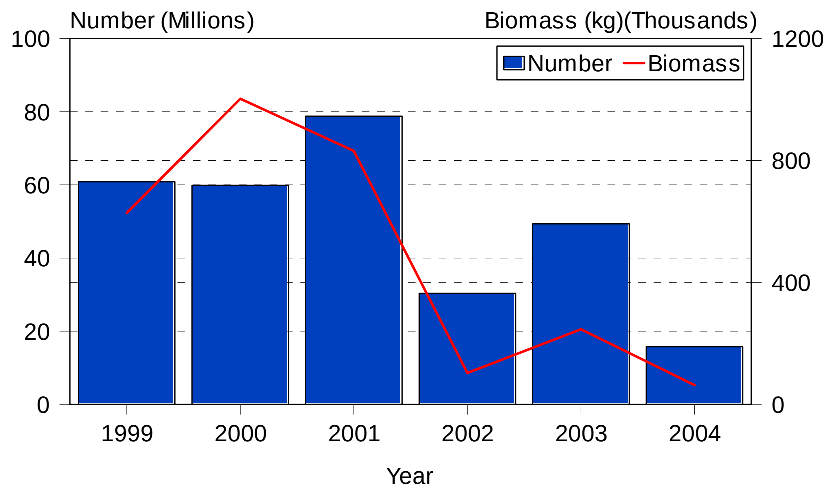

Figure 1 Estimated number and biomass of rainbow smelt in Lake Sakakawea, 1999-2004

2.2.2 Missouri River Downstream of Garrison Dam

2.2.2.1 Thermal Regime

The thermal regime of the Missouri River downstream of Garrison Dam is reflective of the thermal conditions in Lake Sakakawea where the water is drawn into the dam intake for discharge. Summer water temperature data collected in the Garrison Power Plant on the discharge water indicates that the temperature of the water is directly dependent on the discharge rate of the dam and the time of the year. Water temperature data collected over the past two summers indicate that, after exceeding a fluctuating minimum flow, as the dam discharge rate increases the temperature of the discharge water also increases. The maximum daily water temperature of the discharge water also increases during the course of the summer until Lake Sakakawea experiences “fall turnover”. The intake gates to Garrison Dam are located near the lake bottom. An intake channel was excavated upstream of the intake structure during dam construction and is now submerged in the lake. Due to the location of the intake gates and design of the intake structure and channel, the vertical extent of the withdrawal zone in Lake Sakakawea appears to be dependent upon the discharge rate of the dam. The temperature of the discharge water appears to be determined by the extent the vertical withdrawal zone in the lake intersects the hypolimnion, metalimnion, and epilimnion of the lake. As the dam discharge rate increases warmer water from a higher elevation in the lake is drawn into the dam intake and discharged through the dam. Refer to Attachment 1, Final Preliminary Findings of the 2004 Intensive Water Quality Survey of Lake Sakakawea, North Dakota, for a complete discussion of correlation between observed lake temperature, observed flow release temperature, and flow release rate.

As the water discharged from Garrison Dam during the summer flows down the Missouri River it gradually warms in response to climatic and river morphologic conditions (e.g., solar insolation, air temperature, water depth, etc.). Water temperatures monitored during the summer of 2003 and 2004 at Garrison Dam and at the Great River Energy (GRE) water supply intake near Stanton, ND are given in Table 5 below. From Table 5 it appears that the water discharged from Garrison Dam during the summer warms approximately 2.5 °C by the time it reaches the GRE intake near Stanton, ND. Plate 4 shows a plot of hourly water temperatures monitored at Garrison Dam and at the GRE intake, and the hourly discharge recorded at Garrison Dam for a 5-day period during August of 2003. From Plate 4 it is apparent that the water temperature of the Missouri River immediately below Garrison Dam during the summer is largely dependent upon the discharge rate of the dam.

Table 5.
Average Hourly Water Temperature (°C) by Month for 2003 and 2004.[1]

Month	Garrison Dam	GRE near Stanton, ND	Δ T
2003:			
May	-----	-----	-----
June	9.7	12.5	+ 2.8
July	11.6	14.2	+ 2.6
August	12.9	15.1	+ 2.2
September	14.8	16.9	+ 2.1
Average for Jun-Sep Period	12.3	14.7	+ 2.4
2004:			
May	7.8	8.5	+ 0.7
June	10.7	13.1	+ 2.4
July	12.5	15.4	+ 2.9
August	13.9	16.1	+ 2.2
September	15.0	16.6	+1.6
Average for Jun-Sep Period	13.0	15.3	+ 2.3

1 Based on Water Temperatures Monitored in Garrison Dam and at the Great River Energy Intake on the Missouri River near Stanton, ND -- Approximately 20 Miles Downstream of Garrison Dam.

2.2.2.2 Dissolved Oxygen

DO conditions present in the Missouri River downstream of Garrison Dam is reflective of the water quality conditions in Lake Sakakawea where the water is drawn for discharge. As with water temperature, summer DO data collected in the Garrison Power Plant on the discharge water indicates that the DO of the water is directly dependent on the discharge rate of the dam and the time of the year. As the summer progresses, DO levels monitored at Garrison Dam continually decline. During late summer when DO reaches its lowest levels, monitoring data indicate that the lower DO levels are associated with lower dam discharge rates.

During September, water is seemingly being released from Garrison Dam to the Missouri River that does not meet North Dakota's promulgated water quality standards criteria for dissolved oxygen (i.e., < 5 mg/l). This is based on the monitoring of "raw water" in the Garrison Power Plant during 2003 and 2004.

The low dissolved oxygen levels monitored in the “raw water” during September occur when reduced flows are discharged from Garrison Dam. While Lake Sakakawea remains thermally stratified, reduced dam discharge rates appear to pull water with low dissolved oxygen concentrations along the bottom of the submerged intake channel to the outlet gates located at the lake bottom. Low dissolved oxygen levels in the “raw water” do not occur under higher discharge rates. Apparently, the vertical extent of the withdrawal zone in the lake during summer thermal stratification is dependent on the discharge rate of the dam because of the design of the outlet works and intake channel. Epilimnetic water high in dissolved oxygen is drawn down from higher in the water column under higher discharge rates, and colder hypolimnetic water low in dissolved oxygen is drawn along the bottom under lower discharge rates. The possible extent of low dissolved oxygen conditions in the Missouri River below Garrison Dam due to the discharge of low dissolved oxygen water has not been documented, and additional monitoring is planned to determine if a problem exists and to what extent.

2.2.2.3 Garrison Reach Riverine Habitat and Associated Biota

Between Garrison Dam and the headwaters of Lake Oahe, the Missouri river flows for approximately 90 miles; however, due to the record low elevation of Lake Oahe, the entire portion within North Dakota is now riverine habitat (158 miles from the dam to the South Dakota border). Large daily and seasonal stage fluctuations (even hourly changes in river stage) occur in this reach due to the peaking operation of Garrison Dam. However, the peak seasonal flows have been markedly reduced. Because of reduced peak seasonal flows and bank armoring, the natural process of lateral channel migration has been greatly reduced in the Garrison Reach. This has resulted in the river being restricted to one main channel with very few side channels, old channels, or oxbow lakes. Of the islands and bars that do exist in this reach, particularly those near the dam, periodic scouring occurs. This reach supports a much lower density of wetlands (38 acres/mile) than the other inter-reservoir reaches on the upper Missouri (USACE, 2004).

The overall fishery of the Garrison Reach of the Missouri River is represented by 40 documented fish species (Refer to Attachment 5 for additional information). The coldwater discharge and a dramatically modified hydrograph have resulted in a fairly unproductive river from Garrison Dam downstream to near Bismarck. These effects on water quality are most pronounced immediately below the dam and gradually diminish downstream due to tributary inputs (primarily the Knife and Heart Rivers). Because of this, reproduction for most species is very limited within this section of river. Thus, the Garrison Reach can not likely provide for the long-term survival of a number of indigenous fish species such as pallid sturgeon, sturgeon chub, or flathead chub (Welker 2000). However, it provides suitable habitat for the valuable, highly managed sport fishery. The first twenty or so miles below the Dam (downstream to the Stanton area) supports a world-class coldwater fishery due to the size trout and salmon can obtain in this habitat. Also, because the dam releases also maintain open water year round, the tailrace is one of the most utilized fishing access points in North Dakota (Power et. al 2000). The Garrison Dam tailrace area has been stocked with trout and salmon (various species and strains, see Attachment 5, page 49) since 1955 as coldwater species cannot naturally reproduce and can only be maintained by stocking. Currently, seven state records originate from this stretch including a new record 31.5 pound brown trout caught earlier this year. Cold/cool water temperatures coupled with smelt entrainment through Garrison Dam are the reasons for the world-class size of brown, rainbow and cutthroat trout. In addition to tailrace trout and salmon, a generally good but somewhat sporadic walleye fishery exists throughout most of the Garrison Reach most of the time. Walleye is the number one recreational species (in terms of interest and harvest) in this reach, with harvest some years exceeding 100,000 fish. Other gamefish such as sauger, white bass, and channel catfish are also common in the Garrison Reach

More than 50 species of breeding birds depend on the wetland riparian habitat in the corridor, along with 17 species of reptiles and amphibians (USACE 2004). Federally listed interior least terns and piping plovers have been accommodated by flows from the dam via scouring and stage regulation during nesting. On Lake Sakakawea, 2004 data show all nesting sites of piping plovers and least terns were at least 3 miles upstream of Garrison Dam (Greg Pavelka, USACE, pers comm. May 1, 2005). In the Garrison reach of the Missouri River during 2004, data show that there were 18 areas used by least terms for nesting (total of 73 nests,142 adults, 80 fledglings), and 22 areas used by piping plovers (88 nests, 164 adults, 95 fledglings) (Greg Pavelka, USACE, pers comm. May 1, 2005).

2.2.3 Threatened and Endangered Species

According to the FWS North Dakota Field Office home page, the following threatened and endangered species, or their critical habitats occur within McLean and Mercer Counties, North Dakota: Pallid Sturgeon (E); Interior Least Tern (E); Piping Plover (T); Designated Piping Plover Critical Habitat; Bald Eagle (T); Whooping Crane (E); Gray Wolf (T); Black-Footed Ferret (E). All of these species may be found adjacent or within the project area with the exception of the Grey Wolf and Black-Footed Ferret (Roger Collins, FWS pers. comm. May 18, 2005). Thus, our analysis (section 5 and attachment 12, Biological Assessment) does not include those two species. All of the alternatives being looked at have similar impacts to the environment.

2.2.4 Downstream Channel Conditions

The Omaha District Corps of Engineers has conducted numerous studies that evaluate reservoir sediment deposition and Missouri River channel conditions downstream of Garrison Dam. The inflowing Missouri River and tributaries to Lake Sakakawea transport sediments that deposit in the delta region at the upstream end of the reservoir and in the separate tributary arms. Minimal deposition has been observed in the area near the dam. The release of essentially sediment free water from Garrison has resulted in erosion within the Missouri River channel downstream of the dam. Pre-construction estimates predicted that water surface elevations immediately downstream of the dams would lower a maximum of 15 feet at each Missouri River mainstem project (WES, 1998). Current tailwater trends indicate that the Missouri River has lowered approximately 10 feet below the dam (RCC, 2004, pg. 5). Stage trend analysis at Bismarck indicates that the Missouri River has shown limited stage change below 30,000 cfs with a slight aggradation trend at higher flows. An estimated 1 to 2 feet of aggradation has occurred for flows in the 50,000 to 100,000 cfs range. (RCC, 2004, pg. 14).

During the Master Manual update, an analysis was performed to evaluate the cumulative erosion impacts analysis for the Missouri River (WES, 1998). The focus of this study was to evaluate Missouri River erosion rates with respect to the existing water control plan and the preferred alternative. Conclusions of this study were quite lengthy (WES, 1998, pg. 93 – 106). With respect to bed and bank erosion, the principal factor was determined to be the dominant discharge rate.

2.3 DOWNSTREAM FACILITIES

Numerous facilities exist downstream of the Garrison Dam that utilize or are impacted by the Missouri River. Water supply intakes utilize Missouri River water for irrigation and municipal water supply. Industrial users such as power plants utilize Missouri River water for cooling purposes. These users depend on Missouri River water level and water quality. Available data from previous studies identifies a number of facilities (RCC, 2004, pg. E-5). For reference purposes, the approximate location of downstream facilities and other notable features are provided in Table 6.

Table 6. Approximate Location of Downstream Features			
Location	Missouri River Mile Location (1960 mileage)[1]	Distance from Dam (miles)	Approx. Travel Time (hrs)[2]
Garrison Dam	1389.9	-	-
Stanton / Knife River	1375.5	14.4	6
Great River Energy Intake	1372.2	17.7	7
Basin Electric Power Coop. Intake	1371.6	18.3	8
Washburn ND	1354.7	35.2	15
Price ND	1338.6	51.3	21
Montana-Dakota Utilities Co. Intake	1318.2	71.7	30
Bismarck ND USGS Gage	1314.5	75.4	32
Heart River	1311.0	78.9	33
Oahe Reservoir (maximum normal operating pool elev. of 1617 ft msl)	1303.5	86.4	36
North Dakota State Line	1231.9	158	66

1 Location is approximate based on aerial photos and available references.
2 Travel time is approximate based on an estimated average flow velocity of 3.5 ft/sec.

2.3.1 Federal Fish Hatchery

The Garrison Dam National Fish Hatchery, operated by the U.S. Fish and Wildlife Service, is located downstream of Garrison Dam. The hatchery encompasses 209 acres of land and has a total of 64 rearing ponds. Water supply to the fish hatchery is provided from penstocks 4 and 5 through a water supply line. The hatchery uses the supplied water in daily operation to maintain water quality parameters for fish rearing.

2.3.2 Power Plants

The Missouri River reach from Garrison Dam to the upstream end of Lake Oahe includes 6 water intakes that serve 3 power plants (RCC, 2004, pg. E-5). The on-river power plants consist of Basin Electric Power Cooperative, Great River Energy, and Montana-Dakota Utilities Co. The power plants withdraw flow from the Missouri River for plant operations including power plant cooling. Additional power plants are located off the Missouri River that also withdraw river water for cooling in combination with on-site cooling ponds.

2.3.3 Downstream Water Users

Water supply intakes are located on the Missouri River between Garrison Dam and the upstream end of Lake Oahe. Data available from the Master Manual (RCC, 2004, pg. E-5) states that these include 3 municipal water supply facilities, 6 industrial intakes, 77 irrigation intakes, 28 domestic intakes, and 3 public intakes. The municipal water supply facilities serve a population of approximately 70,000 persons.

3. PROBLEM ASSESSMENT

The sport fishery in Lake Sakakawea is of great recreational and economic importance to the State of North Dakota and surrounding region. The primary forage fish utilized by both warm and cold water sport fishes in the lake is the rainbow smelt – a coldwater species. Forecasted pool levels for 2005 project a continued decrease in the pool elevation that is already at a record low level. A corresponding decrease in cold water volume and fishery degradation is projected to occur. If the current sport fishery in Lake Sakakawea is to be maintained through the ongoing drought, measures to protect the cold water habitat in the lake need to be implemented.

3.1 Problem Definition

As described in section *2. Affected Environment* and illustrated on Plates 1 and 2, the intake structure to the Garrison Dam power house allows flow to be drawn from Lake Sakakawea between elevation 1672.0 (msl) to elevation 1772.0 (msl). As a consequence, the water released through the dam throughout the year is drawn from the bottom of the reservoir. During some years, problems can develop when the reservoir releases reduce the cold water habitat remaining in Lake Sakakawea to levels inadequate to support a coldwater sport fishery. Coldwater habitat is defined as water 15 °C or colder with a dissolved oxygen concentration of at least 5 parts per million. Coldwater species such as rainbow smelt and Chinook salmon in Lake Sakakawea require coldwater habitat for long-term survival and optimum growth. Prolonged exposure of coldwater fish species to low oxygen and warm water temperatures leads to increased stress and can ultimately lead to increased mortality including fish kills.

Annually, the volume of coldwater habitat is at it's lowest between mid-August and mid-September; however, it's only during low reservoir pool elevation years when there is an increase of the oxygen demand in the hypolimnion that coldwater habitat becomes limiting for the survival of associated coldwater species (Attachment 2). Consequently, the state of North Dakota has identified a late summer lake elevation of 1825 ft msl as the minimum level to maintain enough coldwater habitat to sustain the coldwater fishery. Elevations below this level do not necessarily mean the coldwater fishery will be completely eliminated, as the timing and duration of the low lake elevation and climatic factors, such as the ambient air temperature, influence the actual impacts to the coldwater fishery. However, the state of North Dakota has determined that prolonged periods below this identified level cause serious damage to the recreational fishery of Lake Sakakawea. As indicated by data collected by the North Dakota Department of Game and Fish, the coldwater fishery in Lake Sakakawea was significantly impacted by the substantial reduction in coldwater habitat which occurred in 2004. A hydroacoustic assessment of the rainbow smelt population in 2004 documented an approximate 70% reduction in their population and biomass since 2003 (Attachment 4). As a result, biological impacts have been exhibited in the recreational fishery including reduced growth rates and survival of predator species (Attachment 5 and Plate 5).

Missouri River reservoir operations are defined in the annual operating plan (RCC, 2004) and are developed in accordance with the revised Master Water Control Manual (RCC, 2004). During prolonged drought periods, a minimum Lake Sakakawea pool elevation of 1825 ft msl may not be maintained. More flexibility and avoidance of cold water habitat loss may be possible if structural changes to the Garrison Dam Intake Structure or the manner in which water is withdrawn from the reservoir are thoroughly evaluated and implemented. If some or all of the water released through Garrison Dam came from above the thermocline (epilimnion), then it might be possible to reduce or eliminate the impacts to the coldwater fishery habitat.

3.2 Anticipated Impacts of No Action

Given the Corps reservoir elevation forecast (Table 1) for the upcoming summer, the recreational fishery in Lake Sakakawea will again be seriously impacted in 2005, due to the lack of coldwater habitat. If no action is taken (structural and/or operational changes are not implemented), the ultimate recovery of Lake Sakakawea's damaged fishery will take several years or longer. As earlier referenced, smelt constitute by far the most important forage base of the reservoirs recreational fishery; when the population 'crashes' recovery can take a very long time. For example, the smelt population in Lake Oahe was decimated in 1997 (due to high discharges through the dam) and still has not recovered despite intense management efforts to facilitate the recovery. Specifically, very liberal regulations in South Dakota to promote additional sport fish harvest to reduce predation on smelt, discontinuation of a walleye stocking program, and water level manipulations have failed to improve the smelt population. A similar scenario is very likely to occur in Lake Sakakawea.

An issue of immediate concern is the status of the Chinook salmon within Lake Sakakawea. This population of salmon is one of three 'disease free' salmon stocks in North America; the only other such "disease free" stocks exist in Lake Oahe and Fort Peck Lake. Since there is no natural reproduction of inland salmon, stocking programs are essential for maintenance of their populations. As both the abundance and condition of Sakakawea's salmon decline rather dramatically, their eventual extirpation is possible. Because of the lack of smelt in Oahe, its salmon fishery is now negligible. As a result, brood source salmon are not currently available from Lake Oahe. The salmon population in Fort Peck Lake is also in very low abundance. Montana biologists have had to use salmon eggs collected from Lake Sakakawea to meet their own needs. Low reservoir elevations will continue to threaten the already reduced salmon populations in both Ft Peck and Lake Oahe. Currently, Lake Sakakawea has the strongest population of disease free salmon in North America, which if lost, will be virtually impossible to replace.

4. ALTERNATIVE EVALUATION

Alternative evaluation was performed to identify feasible alternatives and also determine alternative impacts. Each alternative is described within the following sections to provided limited evaluation details and considerations that were used to develop the selected alternative.

4.1 NO ACTION

The no action alternative results in operation with the existing project facility. No positive benefits or downstream impacts occur as a result of the no action alternative. No action also results in the probable decline of Lake Sakakawea coldwater habitat volume, resulting in continued decline of rainbow smelt and Chinook salmon. The loss of smelt would have an impact on the foodchain of the reservoir, leading to poor growth and higher mortality rates of walleye and all other fishes that utilize smelt as their main forage. There would also be a major decline in recreational revenue generated as a result of a decline in the recreational value of the lake as a walleye and salmon fishery. The effects are more thoroughly described in the *Affected Environment* and *Problem Assessment* sections.

4.2 PHYSICAL MODIFICATION

The purpose of these alternatives is to alter the intake structure or channel to change the elevation at which flow is withdrawn from the reservoir. As previously described within *Section 2. Affected Environment*, the lake vertically stratifies into three zones. Physical modification is proposed to reduce the cold water volume discharged from the reservoir by releasing the warmer water from the upper lake levels and preserving the colder water in the lower lake levels.

4.2.1 Intake Trash Rack Modification

The power tunnels are screened at the upstream end of the water passage by trash racks. These trash racks prevent large objects from entering the penstock and causing serious damage to features such as the wicket gates and turbine. Each of the 5 penstocks has two intake passages for a total of 10 intakes. The trash rack for each of the 10 intakes consists of 7 separate frame sections that are each 14 feet 6 inches high and 20 feet 8 inches wide. The trash rack fits into the trash rack slots at the front of the intake passage piers. A hook for each rack is fixed to the top of the frame. A lifting beam and mobile crane is used to raise and lower each trash rack section.

The existing trash rack could be modified to change the reservoir withdrawal elevation. The trash rack modification would consist of installing a series of plates on the upstream side of the existing trash rack grates. Based on observed reservoir temperature data and projected pool levels for 2005, the lake elevation corresponding to the temperature stratification is expected to be between 1720 and 1740. The trash rack modification requires removal of the existing trash racks, attachment of the blocking plate, and installation of the modified trash racks. Plate 2 illustrates the intake geometry. Due to concerns with hydraulic flow streamlines, head loss, and developed forces, the maximum blocking elevation will be limited. Above elevation 1715, the efficiency of the intake passage is severely reduced due to the constriction through the intake and the additional bend losses that will occur.

The trash rack for each of the separate frame sections (14 feet 6 inches high and 20 feet 8 inches wide) includes 3-1/2” x ¾” bars spaced at 6-3/8” span 4’-10” to either an 18 I 70 beam or 18 C 42.7. Within the frame, the 18 C 42.7 supports the bars at the top and bottom of the trash rack, and the 18 I 70 at 4’-10” spacing support the bars in between. The plates would be attached on the upstream side of the trash racks.

4.2.1.1 Trash Rack Modification Design Plan.

Several factors should be considered when evaluating the number of trash racks to modify and which penstocks should be modified. Since normal low flow releases in the range of 8,000 to 15,000 cfs use only 2 or 3 penstocks, it is preferable to avoid modifying all penstocks to minimize impacts to the hatchery and Garrison power plant cooling. The fish hatchery currently obtains water from penstocks 4 and 5.

The Garrison power plant cooling water is obtained from the raw water loop in the powerplant. Due to the volume of water required for the cooling water operations and water supply demands, the water taps off the scroll cases and penstocks of all operational units are required. Combined with the fact that maintaining a low elevation intake for penstocks 4 and 5 avoids impacts to the fish hatchery, the preferred alternative may be modification of 1 or 2 of the intakes to the penstocks for Units 1, 2, & 3.

4.2.1.2 Evaluation of Forces for Trash Rack Modification.

The trash rack modification requires thorough evaluation of forces to insure structural stability. Trash rack failure would be catastrophic with probable destruction of the turbine and flooding of the power house facility.

Hydraulic Evaluation. Preliminary calculations to evaluate hydraulic forces determined an additional loading of approximately 200 lbs/sq ft. The 200 psf pressure is created by head loss and change in momentum of the water going into the intake. Additional head loss through the reduced flow area at the inlet and the remaining trash rack would lower the effective head by approximately 2 feet. Refer to Attachment 6 for head loss computation details. The reduction in effective head will adversely impact power generation. That is, for an equivalent lake elevation and flow release, a reduction in generated power will occur as the net head available to the turbine will be reduced.

Structural Evaluation. Structural calculations were performed to evaluate the required plate thickness. The structural calculations, based on the information from drawing 878B by Eaton Metal Products Corps dated 9-22-53, indicate that the trash rack structure is more than adequate to resist the added weight of the 3/16” plates and 200 psf hydraulic force. The added weight on the lifting beam for each trash rack covered with the plates is 2,400 lbs based on a top of plate elevation of 1720 (msl). The 2400 lbs is approximately 20% of the original weight of a trash rack. The lifting beam was not checked at this stage of evaluation, but engineering judgment would indicate that the lifting beam along with the crane has the capacity to lift the added weight of the plates. Refer to attachment 6 for the structural computations and computed forces.

During discussion with COE Garrison Project personnel, several issues with the trash rack modification alternative were stated as:

<u>Trash rack removal and plate or blockage installation concerns</u>:

- Trash racks haven’t been removed since the dam was built. Trash or sediment buildup may be a problem.

- Unknown if the trash racks are silted in place from deposited material (e.g., sediment, debris)
- Manufacture removable plate
- Unbalanced flows observed at Bonneville Dam for trash rack stoplog installation ("skating" condition).
- Trash rack slots not "straight up-and-down" – would need to position a crane to remove racks and lower "stop logs".
- Siltation concerns with blocking the lower portion of intake.
- Redesign trash rack lifting beam if plates are used to modify the trash racks.
- The modified trash racks may silt in place and be difficult to remove if installed at the bottom of the trash rack slot.

4.2.1.3 Trash Rack Modification Affect on Maintaining Cold Water Habitat

Modification of the intake to one or more penstocks could have a significant affect on maintaining cold water volume if all releases during the minimum flow period were from a higher reservoir level. For comparison purposes with the optimal cold water habitat volume previously discussed (section 2.1.1), an average daily release rate of 15,500 cfs corresponds to approximately 31,000 acre-feet per day or 930,000 acre-feet per month. The ratio of cold water volume to total volume is difficult to project and will depend on the number of intakes that are modified, lake temperature levels compared to the trash rack modification level, and flow streamlines approaching the modified intake. If two intakes are modified, than all low releases could be made through the modified intake. Using a low flow rate of 12,000 cfs, the release volume is 24,000 acre-feet per day. Therefore, it appears that about 2/3 of the release volume could be impacted by this scenario. Actual impact will depend on number of intakes modified, performance of the modified structure during high flow releases, percent of time that the modified intakes are used for flow releases, and other unknowns such as the flow distribution to the modified intake with respect to lake temperature zones. Assuming that 60% of all releases are impacted, the maximum impact on cold water habitat volume is approximately 18,600 acre-feet per day or 560,000 acre-feet per month.

4.2.1.4 Trash Rack Modification Project Cost and Timeline Estimate

A detailed design and cost estimate was not performed during the initial evaluation process. The cost is variable and will depend on materials, construction methods, and utilization of Garrison Project personnel instead of a contractor. A project timeline has not been determined, but would include the following tasks:

Trash Rack Modification Minimum Tasks
- Limited detail plans and specifications
- Contract negotiations and award
- Underwater exploration (remote and/or diver)
- Trash rack removal
- Install barrier
- Replace trash rack
- Underwater exploration (remote and/or diver)
- Prototype testing
- Modify / complete installation as necessary

Based on the contracting requirements and an estimated construction time length of about 3 - 4 weeks, it appears feasible that construction for this alternative could be completed by 15 July assuming a start date of 9 May for plans and specification preparation.

4.2.2 Intake Channel Curtain

This alternative involves the construction of a submerged temperature control curtain in the intake channel upstream from Garrison Dam to form a temporary channel barrier that blocks the lower portion of the intake channel. The curtain would be anchored to the bottom of the channel, raising the effective withdrawal elevation from the lake to the top of the curtain.

The location of the curtain is proposed to be 2000-2500 feet upstream from the intake structure to avoid concerns with powerhouse operations. At this location, the intake channel bottom elevation is approximately 1670 ft msl with a bottom width of 360 feet. At the top of channel bank, the elevation is approximately 1770 ft msl with a top width of 700 feet. The initial estimate places the curtain top elevation at 1750 feet msl. Under these conditions, the curtain is estimated to be 620' x 80' (approximately 50,000 square feet).

The intake channel dimensions are from the original plans (Plate 1) from the 1940's and may not reflect current channel conditions. The North Dakota State Water Commission (SWC) plans to survey the proposed curtain installation area once the ice goes out.

The SWC has received information from two firms with experience in submerged curtain projects, GSE Construction and Gunderboom, Inc. A summary of the information provided by each company is provided in the following sections.

4.2.2.1 Information Provided by GSE Construction

GSE Construction (GSE), who has successfully completed four projects of this nature for the Bureau of Reclamation on the Lewiston and Whiskeytown Reservoirs in California, has provided cost information for these projects completed in 1992-93. This information includes mobilization and prep work costs, unit pricing for construction materials, and deployment costs. Each of the four curtains varies in size and function.

Costs estimates for the submerged curtain alternative at Lake Sakakawea are based on projects completed by GSE. Maximum costs were used for unit pricing and mobilization. For unit pricing, the number of units required was calculated based on linear foot needs. The project that resulted in the maximum amount of units required was used, with the exception of the drain valves. Approximately twice as many drain valves per square foot were required for a curtain designed for adjustable elevation, with the capability to be situated on the reservoir bottom or floating on the surface.

Several items in the cost estimates provided by GSE were lumped into one unit cost. These items were subsequently broken down into per square foot costs. In addition, several descriptions were listed for the anchors used for the various projects in the information provided. For each of the four projects, the total anchor cost was summed, and the total was broken down into per square foot costs. Again, the maximum cost was used for the lumped items. Attachment 7 outlines the unit cost breakdowns and the cost per square foot estimates, bearing in mind that these are 1992-93 dollars.

A concern is the effect of ice and wind on the Floating Tanks and Surface Stabilization Tanks. Although GSE was not required to submerge these items below the surface in previous projects, they believe it is possible to do so by partially filling the floats with sand or water. If enough weight is provided by the anchors to counteract the buoyant forces, partially filling the floats may not be necessary.

Assuming a similar design to the projects completed, GSE estimates 2.5 months for fabrication of the curtain and other hardware, and 2 months to deploy the curtain. For a large curtain installed in Lewiston Reservoir, each of the concrete anchors required construction onshore and transported individually by barge to the desired location. However, this curtain was installed relatively close to the powerhouse. Another requirement is enough space onshore for curtain fabrication, which would arrive in 2-3 sections.

4.2.2.2 Information Provided by Gunderboom, Inc.

Gunderboom, Inc., who has experience with projects of this nature, provided information that outlines a list of tasks based on what Gunderboom considers to be vital steps in the completion of submerged curtain projects.

Phase I – Preliminary Investigation & Data Analysis

This phase involves site and data/information analysis to determine which of the following, if any, tasks need to be performed.

- High resolution, 3D multibeam survey
- Analyze plans and drawings
- Geotechnical investigation of the bottom/sub-bottom materials
- Current speed and direction
- Prevailing weather conditions
- Site access logistics
- Local/Federal regulations and guidelines

Gunderboom considers the multibeam survey, geotechnical study, and current analysis extremely critical in assessing the channel conditions. Survey of the channel will help reduce dive time, contribute to design and fabrication of the boom, evaluate the proposed location of installation, and determine whether any channel preparation is required before deployment. Geotechnical conditions are also significant in evaluation of channel conditions and design of the anchoring system. A complete bottom seal is necessary to prevent scour. Curtain systems are subjected to forces that are generally calculated by using the formula [(feet/second of current flow)^2 = pounds/square foot of load on boom], where the loads are conveyed to the anchor system. A factor of safety of 1.5 is usually employed.

Weather conditions, site access, and regulations normally focus on deployment restrictions. Deployment may require special consideration and, depending on OSHA and Corps guidelines, a design minimizing diver intervention may be necessary.

Phase II – Field Investigation and Studies

This phase involves conducting the field investigations and studies recommended in phase I. A three dimensional computational fluid dynamics (CFD) model may be necessary to estimate existing flow conditions and simulate flow over the proposed curtain. This tool is also useful for optimization of curtain size and placement for ideal effective withdrawal elevation. CFD model output includes a continuous pressure field, streamlines, velocity vectors, and particle tracking at any location within the model boundaries.

It is emphasized that all or none of these tasks may be necessary, but they illustrate the nature of undertakings that have been conducted in past projects.

Phase III – Final Engineering and Design

Phase I and II activities are employed in Phase III to complete design documentation, calculations, fabrication and site drawings, and anchoring design. Gunderboom is anticipating the design of the entire system being underwater to avoid impacts of ice and wind. Surface buoys would be capable of detachment during the winter by utilizing a multiple layer buoy system and/or acoustic release shackles.

Phase IV – Boom System Fabrication & Materials Procurement

Fabricate and/or obtain boom system, anchoring system, mooring lines, shackles, buoys, and other hardware. The cost of Phase IV is greatly influenced by final design and other requirements.

<u>Phase V – System Deployment</u>

Gunderboom's preliminary timeline estimates the completion of the project to take 3 months. This timeline reflects compression and overlap of some tasks, but Gunderboom believes that this can be accomplished 'by combining tasks and coordinating the work properly'. This timeline also assumes that Gunderboom would complete all Phase I and II tasks. Any information that could be provided by the Corps or state agencies would presumably shorten the completion of the project. If it is decided to move forward with the curtain option, Gunderboom is prepared to assign a senior project manager and superintendents to expedite the project. If requested, Gunderboom usually follows up with annual maintenance.

Attachment 7 includes a work schedule, photos, a standard rate schedule, and examples of multibeam survey maps.

4.2.2.3 Intake Channel Curtain Affect on Maintaining Cold Water Habitat

Construction of the intake channel curtain should have a significant affect on maintaining on cold water volume. Blockage of 100% of the intake channel is probably not likely. In addition, a minimal amount of flow may circumvent the curtain due to the location with respect to the Garrison Dam intake structure. For comparison purposes with the optimal cold water habitat volume previously discussed (section 2.1.1), an average daily release rate of 15,500 cfs corresponds to approximately 31,000 acre-feet per day or 930,000 acre-feet per month. Assuming that 95% of all releases are impacted, the maximum impact on cold water habitat volume is approximately 30,000 acre-feet per day or 900,000 acre-feet per month.

4.2.2.4 Curtain Total Project Cost and Timeline Estimate

The information provided by the two manufacturers is summarized as follows in Table 7:

Table 7
Curtain Project Cost and Timeline Estimate

Firm	Estimated Project Cost ($)	Estimated Completion Time
GSE Construction	975,000 (1992-93 Costs) (1)	4½ Months
Gunderboom Inc.	$1,080,000 (2)	3 Months

1 The costs and timeline includes mobilization and prep work, fabrication and acquisition of construction materials, assembly and deployment.
2 The estimated project cost does not include costs for any Phase II activities that may be required. However, the timeline does include all Phase I and II activities and is subject to overlap of some tasks. Completion time of the project can be shortened depending on the amount of information and data that is available from these phases.

4.2.3 Intake Channel Permanent Barrier

This alternative involves the construction of a permanent barrier to block the lower portion of the intake channel. Methods of blocking the channel involve building a gravel berm or installing a sheet pile wall. Due to construction difficulties associated with the sheet pile wall on the lake bottom and an initial cost assessment, the design selected a gravel berm as the likely least cost method.

4.2.3.1 Gravel Berm Design

The gravel berm would function as an underwater dam, retaining colder water in the reservoir, and allowing water from the upper levels of the reservoir to be released through Garrison Dam. While the berm would function to retain cold water in the reservoir, there would be no operational flexibility, as the structure would be considered a permanent and fixed measure.

The berm would be constructed by placing gravel in the intake channel via barges. The gravel berm, from the intake channel's bottom (elevation 1670 msl) to the top of the designed berm (elevation 1740 msl), would be 70 feet high, and would be placed across the intake channel. The intake channel bottom width varies from approximately 500 feet down to 360 feet across, and it is assumed that the channel's sideslopes are 2H:1V. The berm would be placed at the gravel's natural angle of repose, assumed to be 1H:1V. This berm would require an estimated 230,000 tons of gravel, and the time required to install the berm would be significant. Design details are illustrated in attachment 8.

4.2.3.2 Gravel Berm Affect on Maintaining Cold Water Habitat

Construction of the intake channel gravel berm should have a significant affect on maintaining on cold water volume. Blockage of 100% of the intake channel is probably not likely. In addition, a minimal amount of flow may circumvent the gravel berm due to the location with respect to the Garrison Dam intake structure. For comparison purposes with the optimal cold water habitat volume previously discussed (section 2.1.1), an average daily release rate of 15,500 cfs corresponds to approximately 31,000 acre-feet per day or 930,000 acre-feet per month. Assuming that 95% of all releases are impacted, the maximum impact on cold water habitat volume is approximately 30,000 acre-feet per day or 900,000 acre-feet per month.

4.2.3.3 Gravel Berm Project Cost and Timeline Estimate

The cost for this alternative is estimated to be approximately $5,000,000. Calculations and figures for this alternative are contained in attachment 8. A timeline estimate was not developed.

4.3 MODIFY FLOW RELEASE

Several release patterns or cycles for Garrison Reservoir were investigated to determine which would provide the most favorable conditions for the cold water fisheries in Lake Sakakawea, while still maintaining the project's other authorized purposes of flood control and power generation.

To maximize the cold water habitat, investigations have shown that large releases in the range of 22,000 to 28,000 cfs draw warm water from the epilimnion, while very low releases draw low-oxygenated water from the lower hypolimnion (attachment 1). Therefore, to minimize the impact to cold water habitat, Garrison releases should be either relatively very large or very small while still adhering to the daily release volume. Releases in the middle flow range between the extreme lows and highs tend to draw considerable cold-water habitat from the upper hypolimnion.

4.3.1 Reduce Minimum Daily Flow Release

Investigation of Garrison release policy and past history determined that effectively lowering the minimum daily flow release below current levels would seriously impact downstream water users. Given the high level of water users downstream of Garrison Dam (as described in section *2.5 Downstream Facilities*), this alternative was not further investigated.

4.3.2 Modify Daily Flow Cycle

While maintaining the same daily average flow rate, it may be possible to conserve cold water volume by reducing the duration of all mid range flows that do not reach the high flow mixed temperature range flows. Results for the April monthly reservoir studies prepared by RCC show that for the summer of

2005, mean daily releases from Garrison are projected as 15,500 cfs. Standing Order No. ST-2, 1983 for Garrison reservoir states the minimum energy generation that was developed to provide sufficient minimum flow for the downstream water users as shown in Table 8.

Table 8.
Garrison S.T. 2 – Minimum Energy Requirements[1]

Period	Minimum Energy for Period
4 Hours	300 MWh
5 Hours	400 MWh
6 Hours	550 MWh
7 Hours	700 MWh
8 Hours	850 MWh

1 Garrison Standing Order No. ST-2, 1983.

A new suggested peaking pattern was developed that results in 15,500 cfs mean daily flow and also meets the standing order requirement for minimum releases. The peaking pattern was broken down into two cycles to meet a morning and an afternoon peaking demand. The developed peaking pattern is illustrated in tabular form in Plate 6. A figure was developed to compare the historic 2004 daily peaking pattern with the proposed revision and is also illustrated in Plate 6.

4.3.2.1 Modify Daily Flow Cycle Affect on Maintaining Cold Water Habitat

The affect on maintaining cold water habitat is difficult to estimate for this alternative. Referring to Plate 6, the positive benefit of this alternative may be viewed as the difference between the 2005 and 2004 plotted values. Cold water habitat volume is conserved when the mid flow range is reduced. However, it should be noted that 2004 had a higher average daily flow rate. Based on Plate 6, it appears that about 3,000 to 5,000 cfs falls within this range for a duration of about 6 to 12 hours. Using these values, the daily volume that could be impacted varies from 1,500 acre-feet to 5,000 acre-feet. For comparison purposes with the optimal cold water habitat volume previously discussed (section 2.1.1), an average daily release rate of 15,500 cfs corresponds to approximately 31,000 acre-feet per day or 930,000 acre-feet per month. Therefore, based on projections that the impact varies from 5% to 16% of all releases, the maximum impact on cold water habitat volume varies from approximately 1,500 to 5,000 acre-feet per day or 45,000 to 150,000 acre-feet per month.

4.3.2.2 Modify Daily Flow Cycle Project Cost and Timeline Estimate

The flow release modification cost is related to power generation impacts. Since the total daily volume remains the same, any cost would be associated with reduced power generation during peak daily demand time and a reduced flexibility in the daily operating schedule. The timeline to implement this revision is related to coordination between affected parties including the Corps of Engineers and Western Area Power Administration (WAPA). However, implementation of a revised flow release in early summer should be feasible.

4.4 LAKE INSTALLATION

4.4.1 Lake Mixing Alternatives

Lake mixing has been widely used for water quality management. It is primarily used in lakes that thermally stratify and exhibit anoxic conditions in the deeper water. Mechanical or hydraulic means are used to disrupt thermal stratification in a lake by lifting deeper water to the lake surface. This allows for aeration of the deeper water by exposing it to the atmosphere at the lake surface. The mixing can be targeted at total lake stratification or at a localized region of a lake. It has been used to improve the quality of water discharged from dams that draw anoxic water off the bottom of a lake by destratifying local areas near the dam inlet. Because lake mixing disrupts thermal stratification by mixing the hypolimnion and epilimnion, the mixed water will have a temperature intermediate to the temperature of the hypolimnion and epilimnion.

Lake mixing is not believed a viable short term remedy for the enhancement of the cold water habitat in Lake Sakakawea. Mixing a localized region of the lake could raise the dissolved oxygen levels in the deeper water of that region, but it would also increase the temperature of the deeper water. Any benefit derived from increasing the dissolved oxygen levels in the deeper water would likely be more than offset by the loss of cold water in the mixed area.

Due to the issues with this alternative, an estimated project cost and implementation time was not developed.

4.4.2 Re-Oxygenation Alternatives

Hypolimnetic aeration or oxygenation has been used to improve dissolved oxygen conditions in the hypolimnion of lakes that thermal stratify and exhibit low hypolimnetic dissolved oxygen levels. The technique involves the direct injection of air or molecular oxygen into the water column. It has been applied in situations to meet water quality criteria applicable to dam releases, and to provide suitable habitat within a lake for the survival of aquatic life. The design of a hypolimnetic aeration/oxygenation system may vary, but typically includes an oxygen supply on shore, distribution system to aerators (i.e., small bubble diffusers), and injection of oxygen over an appropriate area to meet a required volume of re-oxygenated water. Applications of this technique have generally indicated that the injected oxygen influences the dissolved oxygen levels in the lake up to 10 meters above the diffuser.

Re-oxygenation could possibly be used to restore optimal cold water habitat in Lake Sakakawea that was lost due to consumption of dissolved oxygen in the hypolimnion. Depletion of dissolved oxygen in the hypolimnion moves up from the lake bottom as the summer progresses. As pool levels drop in Lake Sakakawea, the top elevation of the hypolimnion will also drop as the volume of the hypolimnion decreases. Hypothetically, dissolved oxygen levels less than 5 mg/l migrating up from the bottom could pass the 15°C water temperature "isopleth" and eliminate optimal cold water habitat in the lake. If this were to occur, re-oxygenation of the hypolimnion could be used to restore a refugium region of optimal cold water habitat in the lake. Re-oxygenation of the hypolimnion, while effecting dissolved oxygen levels, would not affect water temperatures.

The areal extent of a distribution system of in-lake aerators that would be needed to maintain a refugium region of optimum cold water habitat was estimated based on a 10-meter re-oxygenation zone above the diffuser. To maintain a volume of 50,000 acre feet of re-oxygenated water would require approximately 1,524 acres of diffusers – a square area of approximately 1.5 miles on a side. Installation and operation of such a diffuser system does not appear to be a feasible short term alternative.

Due to the issues with this alternative, an estimated project cost and implementation time was not developed.

4.5 LONG TERM ALTERNATIVES

The focus of this evaluation is on short term alternatives that could be implemented in 2005. Other alternatives that would take much longer to evaluate and construct could be implemented that would successfully resolve water quality issues and identified impacts. An example of a long term alternative is modification of the intake structure to allow selective withdrawal from different lake zones. Proper evaluation and design of an alternative such as modifying the intake structure would require substantial time and resources that does not meet the short term implementation objective. For these reasons, long term alternatives were not addressed. However, studies have been initiated to address these issues.

Long-term water quality management planning is being pursued at the Garrison Project and Lake Sakakawea in accordance with the Corps Program Management Plan for Implementing the Omaha District's Water Quality Management Program. Pursuant to this effort intensive water quality surveys have been conducted or are planned. The water quality data collected through the intensive surveys will be used with available historic information to facilitate application of the CE-QUAL-W2 Hydrodynamic and Water Quality Model, develop a project-specific water quality report, and prepare a needs assessment report for the project. The tentative schedule for completing these tasks are: 1) conduct intensive water quality surveys – 2003, 2004, and 2005; 2) application of the CE-QUAL-W2 model – 2005; 3) prepare project-specific water quality report – 2006; and 4) develop needs assessment report – 2007.

The project-specific report will provide basic information on all pertinent factors affecting water quality and the aquatic environment at the Garrison Project. The technical report will contain a general project description and include watershed characteristics; physical project elements affecting water quality; water quality management objectives; data collection activities; evaluation of water quality conditions; effect of water control operations on water quality; and a description of the physical, chemical, and biological processes that take place in the project, affect the project, or are affected by the project. The report will comprehensively describe project water quality and the project's impact on water quality. It will identify specific concerns, problems, or opportunities. The project-specific report will describe historical and current water quality conditions and will be developed along the lines of an owner's manual for the project.

The needs assessment report will describe the Garrison Project based on the water quality and aquatic environmental needs of the project and the investment of resources required to meet those needs. The report will identify all the needs of the project related to its water quality and water quality management. The report will identify existing problems (e.g., sedimentation, eutrophication, watershed management, erosion, fisheries, wetlands, etc.), causes, appropriate solutions and alternatives, and the estimated costs and benefits of implementation. The report will be provided to the Omaha District's Operation Division and the Garrison Project manager for consideration and appropriate inclusion in the project's water control plan and master plan. The report will also be provided to interested state and local agencies for their consideration.

5. IMPACTS AND CONSTRAINTS

A number of potential impacts have been identified for the various alternatives. Alternative implementation has the potential to cause impacts to Missouri River water users due to changes in flow quantity and quality. The location of the identified impacts are the Garrison power plant, Garrison Dam Fish Hatchery, downstream water users, and downstream channel water quality. Each impact is evaluated within the following sections with a brief description, how the impact occurs, options to mitigate the impact, and an impact assessment related to economic cost or other relevant parameters.

5.1 GARRISON POWER FACILITIES AND RELEASES

5.1.1 Garrison Powerplant Cooling Water

Alternatives that cause an increase in penstock water temperature will adversely impact water users and limit cooling capability. Impacts will vary for the different alternatives depending on factors such as water temperature raise and how many penstocks are affected.

The existing powerhouse equipment cooling systems were investigated to see what effect an increase in cooling water input temperature from 18 ^{o}C to 22 ^{o}C would have on the systems.

Generator Coolers

Review of the generator coolers for Units 1, 2, and 3 shows that the coolers are designed to operate effectively up to an input water temperature of 22.2 ^{o}C (72 ^{o}F) at 5455.31 l/m (1200 GPM) per unit.

Units 4 & 5 however have a problem. The existing coolers are having difficulties removing the current heat load. We have experienced unit restrictions of about 82 MW with 18 ^{o}C cooling water. Increasing the water temperature an additional 5 ^{o}C, to 22 ^{o}C, will result in unit restrictions of about 70 MW on Unit 4 and 5.

Bearing Coolers

Review of the thrust bearing coolers shows that they are designed to operate effectively up to the 22^{o}C.

Transformer Coolers

Limited data has been found on the existing transformer cooler. These coolers were re-tubed about 15 years ago. No cooling problems were noted in the 2004 major rehabilitation report, but thin cooler shells were indicated. It is assumed the coolers are capable of operation at or above 22^{o}C. If increased water flow is required, the condition of the shell would be of concern due to the increased chance of cooler leakage.

5.1.1.1 Impact Summary.

Increased water temperature above 18^{o}C will require a lower generator output on units 4 and 5. It is not possible for the cooling water loop to supply all the units with cool water. Due to the high number of variables, a detailed cost evaluation for this impact is not possible. The cost will be dependent upon items such as replacement power costs, time of occurrence, and flow release. A rough estimate was performed to provide an indication of the potential cost impact. Generated power varies with a number of factors including flow rate and reservoir pool level. Using an average based on data from the spring of 2005, the Garrison powerplant generated approximately 240 to 250 kwh per cfs of flow release. For an average daily flow of 15,500 cfs, the generated power is projected to be nearly 4000 mwh per day. Using the values, the estimated cost range, as shown in table 9, is from $360,000 to $3,600,000.

Table 9.
Garrison Power Reduction Potential Cost Range

Power Reduction	Generated Power (kwh/cfs)	Average Daily Flow[(1)] (cfs)	Daily Gen (mwh)	Power Reduction (%)	Replacement Power Cost($/mwh)[(2)]	Monthly Cost ($)	Total Cost[(3)] ($)
Low	250	15500	3875	1	100	120,000	360,000
Medium	250	15500	3875	5	100	580,000	1,740,000
High	250	15500	3875	10	100	1,200,000	3,600,000

1 Average daily flow is based on April projections by RCC. Value will be revised to reflect actual runoff.
2 Replacement power cost is estimated to vary from $50 - $150/mwh depending upon time and duration.
3 Total cost is based on 3 month duration.

5.1.1.2 Alternatives with Impacts.

Alternatives that would impact the Garrison powerplant cooling water are summarized in table 10.

Table 10. Alternatives that Impact Garrison Powerplant Cooling Water		
Physical Modification		Potential Impact
	Intake Trash Rack Modification	Varies with number of intakes modified and flow release scheme, could be minor to major
	Intake Channel Curtain	Maximum impact, all cooling water affected
	Intake Channel Permanent Barrier	Maximum impact, all cooling water affected
Modify Flow Release		
	Reduce Minimum Flow Release	Impact varies depending on flow release scheme, could be minor
	Modify Daily Flow Cycle	Impact varies depending on flow release scheme, could be minor
Lake Installation		
	Lake Mixing	Impact varies from minor to major depending on lake temperature and success of mixing
	Re-Oxygenation	No impact identified

5.1.1.3 Impact Reduction.

Due to the location and short time duration, no feasible means of reducing the anticipated impacts are available.

5.1.2 Garrison Powerplant Efficiency

Powerplant efficiency losses would occur if implementation of an alternative caused additional head loss as flow travels through the intake structure and penstocks to the turbines. As a result, the net head available to generate power would be reduced. As an example, the trash rack modification causes additional head loss by increasing flow velocity and adding two bends as flow travels through the intake structure. This increased head loss will reduce the net head that is available to the turbines.

5.1.2.1 Impact Summary.

Evaluation of the impact was performed for two scenarios as the impact varies with how the flow release rate is adjusted to accommodate the additional head loss. Note that Garrison flow releases must conform to the operating plan that is developed by RCC (RCC, 2004).

<u>Assumption No. 1 – Maintain the Same Gate Opening</u>

For changes in head loss of less than 5%, it is generally assumed that the turbine efficiency stays the same. The hill curve for these turbines shows that this is a valid assumption. The change in output can then be calculated from the theoretical relationships, in this case the ratio of net head and the head loss raised to the 3/2's power. The loss of output was evaluated for a range of net head vs. head loss conditions as shown in Table 11.

Table 11. Powerplant Head Loss – Output Comparison		
Beginning Net Head (ft)	Head Loss (ft)	Loss of Output (percent)
163	1	0.92
163	2	1.83
163	3	2.75
150	1	1.00
150	2	1.99
150	3	2.98
140	1	1.07
140	2	2.14
140	3	3.20

Assumption No.2 – Increase Turbine Gate Opening to Maintain Output.

The theoretical relationships cannot be used in this case since they are only valid for constant gate openings.

The hill curve shows that near peak efficiency the change in efficiency is negligible. For a three-foot head loss the increase in flow required to maintain the same output at the lower head is approximately 1%. The percent loss in output over that available from passing the water at the higher net head is approximately equal to the values listed previously for assumption no. 1.

At gate openings near the turbine cavitation limit there is a loss of efficiency with increasing gate of approximately 1% for three feet of head. For a three-foot head loss an approximate 2% increase in flow would be required to maintain the same output. The percent loss in output over that available from passing water at the higher net head is approximately 1% higher than the values listed previously in table 11.

Summary
The different scenarios that were examined indicate that an increased head loss of not more than 3 feet will cause an output loss in the range of 1 to 4 percent. The actual output loss will vary depending upon a number of factors including release flow rate and duration, number of intakes modified, actual head loss, and etc. Converting the output loss to an actual cost involves further assumptions including time of occurrence, replacement power cost, and etc. Due to the high number of variables, a cost evaluation was not performed for this impact. Refer to table 9 for an estimated cost range.

5.1.2.2 Alternatives with Impacts.

Alternatives that would cause an additional head loss are related to physical modification of the trash rack only. The impact of the modification would vary depending on the number of intakes modified, that actual head loss observed (will likely be different from the estimated), and the power generation duration for the modified condition. Alternative impacts to the Garrison powerplant efficiency are summarized in table 12.

5.1.2.3 Impact Reduction.

Construction of a modified intake could reduce the impact of additional head loss. However, the extremely high construction cost of a revised intake tower within Lake Sakakawea and the time duration make any reduction effort infeasible for this evaluation.

5.1.3 Peak Generation

Powerplant daily peaking generation changes would occur if implementation of an alternative caused a reduction in generated power compared to the normal condition during the peak hours. This does not include efficiency losses or reduced generation due to temperature cooling problems described in the previous sections. Since the daily flow rate remains the same for all alternatives, the scenario that causes a generation loss is if the daily release pattern causes a reduction in generated power during peak load periods.

Table 12.
Alternatives that Impact Garrison Powerplant Efficiency

Physical Modification		Potential Impact
	Intake Trash Rack Modification	Varies with number of intakes modified, duration of modified intake flow
	Intake Channel Curtain	None – No additional head loss expected
	Intake Channel Permanent Barrier	None – No additional head loss expected
Modify Flow Release		
	Reduce Minimum Flow Release	None – No additional head loss expected
	Modify Daily Flow Cycle	None – No additional head loss expected
Lake Installation		
	Lake Mixing	None – No additional head loss expected
	Re-Oxygenation	None – No additional head loss expected

5.1.3.1 Impact Summary.

As this impact does not appear substantial for most of the alternatives, an impact summary table was not prepared. As the cost is highly variable and dependent upon replacement power, an estimate was not performed.

5.1.3.2 Alternatives with Impacts.

The modify flow release alternative may have an impact to daily peaking generation. The amount of impact is dependent upon actual operation.

5.1.3.3 Impact Reduction.

As this impact is caused by operation changes, no feasible impact reduction is possible.

5.2 WATER QUALITY AND HABITAT

5.2.1 Lake Sakakawea

For both temperature and DO, summer data collected in the Garrison Power Plant on the discharge water indicates that the discharge water quality is directly dependent on the discharge rate of the dam and the time of the year (Attachment 1). Therefore, alternatives that impact the discharge rate and withdrawal level from within the pool are expected to impact optimal cold water habitat volume within Lake Sakakawea.

5.2.1.1 Impact Summary.

None of the alternatives result in a reduction of daily release volume and will not affect pool level. It should be noted that the impact of any alternative on cold water habitat volume is highly speculative. Actual cold water habitat volume within Lake Sakakawea during 2005 will be highly dependent upon numerous conditions that are not directly affected by alternative implementation. A comparison method between alternatives illustrates the potential impact and which alternatives are projected to have a higher impact. Also, while the alternatives may conserve the volume of cold temperature water, the occurrence of low DO water is not addressed by most alternatives.

5.2.1.2 Alternatives with Impacts

The general anticipated affect that each alternative may have in protecting cold water habitat is summarized within Table 13. Refer to section 4 to review the possible impact for each individual alternative.

Table 13.
Alternatives that Impact Lake Sakakawea Cold Water Habitat Volume

Physical Modification		Potential Affect
	Intake Trash Rack Modification	Varies with number of intakes modified and flow release scheme, projected to affect 60% of all release volume, maximum impact estimated as 18,600 ac-ft per day and 560,000 ac-ft per month
	Intake Channel Curtain	Projected to affect 95% of all release volume, maximum impact estimated as 30,000 ac-ft per day and 900,000 ac-ft per month
	Intake Channel Permanent Barrier	Projected to affect 95% of all release volume, maximum impact estimated as 30,000 ac-ft per day and 900,000 ac-ft per month
Modify Flow Release		
	Reduce Minimum Flow Release	Impact varies depending on flow release scheme, due to implementation issues, volume not estimated
	Modify Daily Flow Cycle	Impact varies depending on flow release scheme, projected to affect 5 - 16% of all release volume, maximum impact estimated as 1,500 to 5,000 ac-ft per day and 45,000 – 150,000 ac-ft per month
Lake Installation		
	Lake Mixing	Impact varies from minor to major depending on lake temperature and success of mixing, due to implementation issues, volume not estimated
	Re-Oxygenation	Primary impact is on dissolved oxygen levels, due to implementation issues, volume not estimated

5.2.1.3 Impact Reduction.

No foreseeable negative impacts to Lake Sakakawea.

5.2.2 Missouri River Downstream of Garrison Dam

5.2.2.1 Impact Summary.

If structural and/or operational changes are implemented and riverine summer water temperatures increase, there should be few if any negative impacts. In fact, warmer water may improve the overall condition of the fishery. A slightly warmer river would certainly enhance river productivity although ramping for hydropower will continue to dampen some of these positive effects. In addition, warmer water temperatures would increase the reproductive potential of many species in the river. A slightly warmer river would result in a more predictable and sustainable recreational fishery (esp. walleye) from Garrison Dam downstream to near Bismarck. Lastly, the relatively rare native large river species such as paddlefish and blue sucker would also likely benefit especially with warmer water temperatures in the proximity of the tributaries (e.g. Knife River).

Maintenance of the coldwater tailrace fishery (primarily brown and rainbow trout strains) should be obtainable if the water temperatures don't get too high for a prolonged period. However, dependent upon the type and timing of any structural and/or operational change, entrainment of smelt may be reduced and thus, over the long-term, sustaining the world-class size of some of the trout species that are occasionally caught by anglers may be difficult.

5.2.2.2 Alternatives with Impacts.

Alternatives that raise Missouri River temperature below Garrison Dam may impact the downstream tailwater fishery and river fishery. The extent of this impact will be variable as previously described and shown in table 14.

Table 14.
Alternatives that Impact the Riverine Habitat/Aquatic Organisms

Physical Modification		Potential Impact
	Intake Trash Rack Modification	Increase in temperature – Some benefit to native organisms; impacts to salmonid fishery minimal
	Intake Channel Curtain	Greatest increase in temperature (likely $\leq 10^{o}F$) – Most beneficial to native organisms; impacts to salmonid fishery minimal
	Intake Channel Sheet Pile Wall	Greatest increase in temperature - (likely $\leq 10^{o}F$) - Most beneficial to native organisms; impacts to salmonid fishery minimal.
Modify Flow Release		
	Reduce Minimum Flow Release	Increase in temperature – Some benefit to native organisms; impacts to salmonid fishery minimal
	Modify Daily Flow Cycle	Increase in temperature – Some benefit to native organisms; impacts to salmonid fishery minimal
Lake Installation		
	Lake Mixing	Greatest increase in temperature (likely $\leq 10^{o}F$) – Most beneficial to native organisms; impacts to salmonid fishery minimal
	Re-Oxygenation	No impact.

5.2.2.3 Impact Reduction.

No foreseeable downstream negative impacts.

5.2.3 Threatened and Endangered Species

Unless otherwise noted, the impacts mentioned apply to all alternatives. Analysis specific to the selected alternative as described in Section 6 can be found in the Biological Assessment, attachment 12.

5.2.3.1 Pallid Sturgeon – Endangered

Populations of the fish have declined primarily due to habitat loss and modification from construction of dams and channelization of rivers. Because the construction activities would take place within Lake Sakakawea, a non-flowing habitat they are unlikely to use, the pallid sturgeon will not be directly affected by construction activities. However, because the project alternatives (except for re-oxygenation) will result in the Garrison intake drawing warmer water, the releases into the river will also be warmer. As the river is cooler now than it was naturally, warmer water will provide a more natural setting for sturgeon, and should increase the production of invertebrates and fish in the river to levels that would be closer to natural (food items of the sturgeon). The trash rack modification alternatives could negatively affect the captive pallid sturgeon that exist within Garrison Fish Hatchery because water from penstocks 4 and 5 provide water to the hatchery and allow for the maintenance of water quality. Modification of this alternative to avoid penstocks 4 and 5 would be preferred as they would not impact hatchery sturgeon.

5.2.3.2 Piping Plover – Threatened

In North Dakota the piping plover occurs generally from April-September for breeding purposes, utilizing large extents of sand or gravel beaches largely void of vegetation. The proposed project is planned to occur during the early summer timeframe, when piping plovers are expected to be present in the Lake Sakakawea area. However, no least terns or piping plovers have been found to nest within 3 miles of Garrison Dam on Lake Sakakawea as of 2004 (Greg Pavelka, USACE, pers. comm., March 2, 2005). As any modifications will take place on the Lake Sakakawea side of the dam, the disturbances of the proposed project is unlikely to affect active nesting sites. Also, as the work is taking place during drought and falling lake levels, the available suitable non-vegetated nesting and foraging habitat around the reservoir is in great abundance.

Piping plover also utilize the Garrison Reach of the Missouri River. In the Garrison Reach, there were 22 areas used by piping plovers (88 nests, 164 adults, 95 fledglings) (Greg Pavelka, USACE, pers comm. May 1, 2005). Terns that utilize this reach may actually benefit from the warmer summer releases of all of the alternative (except re-oxygenation) because of potential increased invertebrate and fish productivity of the reach. Preliminary results of a piping plover forage ecology study (Dr. Jim Frasier, Virginia Tech, pers. comm., May 2, 2005) show that Invertebrate biomass in saturated and moist substrates was lower on the Garrison Reach (hypolimnetic dam, hydro-peaking) than at Gavins Point Reach (hyperlimnetic dam, non-hydro peaking), suggesting that least tern foraging site quality might increase downstream from Garrison Dam if water temperatures were increased (more similar to Gavins).

5.2.3.3 Interior Least Tern – Endangered

In North Dakota the least turn occurs generally from May-August for breeding purposes. It uses sparsely vegetated sand bars along the Missouri River for nesting and resting and foraging during these spring and summer months. The proposed project is planned to occur during these times. However, no least terns or piping plovers have been found to nest within 3 miles of Garrison Dam on Lake Sakakawea as of 2004 (Greg Pavelka, USACE, pers. comm.. March 2, 2005). As any modifications will take place on the Lake Sakakawea side of the dam, the disturbances of the proposed project is unlikely to affect active nesting sites. Also, as the work is taking place during drought, the available non-vegetated nesting habitat around the reservoir is in great abundance.

Least terns also utilize the Garrison Reach of the Missouri River, and are actually more likely to utilize the riverine habitat as opposed to the habitat available in the reservoir due to its feeding behavior. In the

Garrison Reach, there were 18 areas used by least terms for nesting, with a total of 73 nests found in these areas, and a total of 142 adults and 80 fledglings (Greg Pavelka, USACE, pers comm. May 1, 2005). The alteration in the physical and chemical habitat components of the Missouri that has resulted in changes to habitat used by least terns has also led to changes to the fish community that they forage upon. While the degree to which these changes in forage fish abundance and distribution may have affected tern population trends have not been quantified (USFWS 2003), it is likely that terns that utilize this reach may actually benefit from warmer summer releases of all of the alternatives (except re-oxygenation). Increased water temperature will likely increase in invertebrate and fish productivity, and increase the availability of fishes of suitable forage size for least tern.

5.2.3.4 Bald Eagle – Threatened

Bald eagles commonly use large trees adjacent to rivers and lakes as foraging perches, day resting sites, and night roosts over a large range in the summer months. Wintering populations tend to be more concentrated, but are usually found in areas along available open water, such as the habitat provided in the tailrace of the Garrison Reach. Construction will not be completed during the winter months, so large concentrations of eagles that may be present below Garrison Dam will not be disturbed. Construction work could create minor noise disturbances to individuals in early summer months, but the displacement would be short-term and considered insignificant.

5.2.3.5 Whooping Crane – Endangered

The species is an uncommon spring and fall migrant in North Dakota. The decline of its populations is related to its nesting and wintering habitat loss due to land use changes that occurred extensively throughout its range in the late 19th and early 20th centuries. Some population decline can also be blamed on excessive hunting for their plumage. Because the project will be short term in nature, and whooping cranes are an uncommon migrant in North Dakota, no adverse impacts are expected.

5.2.3.6 Critical Habitat Piping Plover

Critical habitat for piping plovers was designated in 2002 for the northern Great Plains breeding population. This designation includes the Missouri River and its reservoirs in North Dakota and their sparsely vegetated shorelines, peninsulas, and islands. Lake Sakakawea and the Garrison Reach meets the criteria for this designation.

5.2.4 Downstream Channel Conditions

A previous study evaluated impacts of reservoir releases and alternative reservoir operating plans on channel bed and bank stability. Conclusions of this study were quite lengthy (WES, 1998, pg. 93 – 106). With respect to bed and bank erosion, the principal factor was determined to be the dominant discharge rate. Therefore, an alternative that varies the daily flow cycle or flow temperature but does not alter the daily flow volume is not expected to cause a significant difference in channel bed and bank erosion.

5.2.4.1 Impact Summary.

Significant impacts that differ from existing conditions for any of the alternatives are not anticipated.

5.2.4.2 Alternatives with Impacts.

Significant impacts that differ from existing conditions for any of the alternatives are not anticipated.

5.2.4.3 Impact Reduction.

Reduction of any observed impacts is not anticipated to be necessary. In the event that unanticipated impacts were to occur, it may be possible to construct minor remedies at a few selected sites. However, implementation on a reach wide basis from Garrison Dam to the Oahe headwaters is not feasible.

5.3 Downstream Facilities

5.3.1 Federal Fish Hatchery

The Garrison Dam National Fish Hatchery, located downstream of the Garrison Dam, receives water supply from penstocks 4 and 5 through a 20 inch diameter water supply line. The hatchery water use rate varies by season with a maximum rate of about 6800 gpm during the May to mid-July period. The rate declines to about 4000 gpm through the end of September. The hatchery uses the supplied water in daily operation to maintain water quality parameters for fish rearing. Impacts to the hatchery occur if an alternative impacts the water quality within penstocks 4 and 5.

5.3.1.1 Impact Summary.

Impacts compiled by fish hatchery staff (Gravening/Holm Correspondence, 2005) are summarized in Table 15.

Table 15.
Garrison Dam National Fish Hatchery Impact Summary

Operating Range[1]	Temperature Range	Impact
Optimum	10 – 15 °C	No impact
Marginal	15 – 20 °C	Production still possible but at a much reduced level, will require oxygen supplementation
Unacceptable	20 – 24 °C	Temperatures in this range make production at any level impractical
Lethal	Above 24 °C	Salmonid species cannot exist at these temperature levels

1 Temperatures that slipped into the unacceptable or lethal levels for even a matter of minutes could kill entire raceways of fish that were stocked at densities based on temperatures not exceeding the optimum or marginal ranges.

5.3.1.2 Alternatives with Impacts.

Alternatives that would impact the fish hatchery are those that raise the water temperature within penstocks 4 and 5. These alternatives include options that modify the intake channel, trash rack, or flow release if penstocks 4 and 5 are used to achieve high flow releases. Of these alternatives, modification to the intake channel would raise the water temperature in penstocks 4 and 5 for all release scenarios and would have the highest impact. Alternative impacts to the fish hatchery are summarized in table 16.

Table 16.
Alternatives that Impact Garrison Dam National Fish Hatchery

Physical Modification		Potential Impact
	Intake Trash Rack Modification	Varies with no. of intakes modified, could be none
	Intake Channel Curtain	Maximum impact, all cooling water affected
	Intake Channel Permanent Barrier	Maximum impact, all cooling water affected
Modify Flow Release		
	Reduce Minimum Flow Release	Impact varies depending on flow release scheme and penstocks used for flow release
	Modify Daily Flow Cycle	Impact varies depending on flow release scheme and penstocks used for flow release
Lake Installation		
	Lake Mixing	Impact varies, may be major
	Re-Oxygenation	No impact identified

5.3.1.3 Impact Reduction.

Assuming that the penstock water temperature is non-desirable, methods of impact reduction consist of delivering the required fish hatchery flow from an alternate source. Fish hatchery representatives indicated that well water was tried previously without success due to problems with water quality. In addition, the well is not projected to be able to meet the hatchery maximum water use rate of 6800 gpm. In order to meet the water quality of existing flow supplied to the hatchery, using Lake Sakakawea water is a logical option. It may be possible to install an access point in the lake with a portable pump and water supply line to the hatchery. Since the lake level is low, locating the temporary supply line through the spillway channel may be an option. Cost projections for this option have not been performed.

5.3.2 Power Plants

The State of North Dakota, Department of Environmental Health, transmitted letters requesting an evaluation of impacts resulting from an increase in Missouri River water temperature of 5^{o}C (10^{o}F). Responses were received from three power plants, Basin Electric Cooperative, Great River Energy, and Montana Dakota Utilities Co. These letters are included as Attachment 9. Additional powerplants use Missouri River water for cooling including powerplants at Coal Creek and Milton Young. However, these plants are located farther from the river and use a pipe line to deliver Missouri River water to a cooling pond. Therefore, temperature change impacts are not expected.

5.3.2.1 Impact Summary.

Identified impacts consist of reduction in operations to ensure compliance with the NPDES permit limit for maximum discharge temperature. A slight decrease in generation efficiency may also occur due to a reduction in cooling efficiency. Reponses also identified impacts to operation and maintenance costs due to system biofouling (related to increase temperature) and cooling system costs for chiller, pumps, air compressor, and etc. Replacement power cost is identified to cost between $10 to $150/MWh. At the peak power demand time, the replacement cost is likely to be near $150/MWh. The impact cost summary is included in table 17.

Table 17.
Downstream Power Plant Impact Summary

Power Plant	Cost [1]	Notes
Basin Electric Power Coop. Leland Olds Station	$850,000 based on $50/MWh	Based on reduction of 17,000 MWh
Great River Energy Stanton Station	$12,000 per 80 MWH, estimate based on $150/MWh	Lower output by 60%, a drop of 80MW is projected, O&M, not included
Montana Dakota Utilities RM Heskett Station	$2,608,900 annually	Includes loss of reserve capacity, and replacement cost impact of decreased efficiency. O&M not included.

1 Cost impact is extracted from power plant response letters. Cost impact varies greatly depending upon assumptions regarding lost power. Cost impacts ignore any increased operation and maintenance costs.

5.3.2.2 Alternatives with Impacts.

Alternatives that would impact the downstream powerplants are those that raise the water temperature within the Missouri River by an appreciable amount. These alternatives are summarized in table 18.

Table 18. Alternatives that Impact Downstream Powerplants Cooling Water		
Physical Modification		Potential Impact
	Intake Trash Rack Modification	Varies with actual temperature change. Expected to be minor.
	Intake Channel Curtain	Maximum impact. All flow releases affected.
	Intake Channel Permanent Barrier	Maximum impact. All flow releases affected.
Modify Flow Release		
	Reduce Minimum Flow Release	Varies with actual temperature change. Expected to be minor.
	Modify Daily Flow Cycle	Varies with actual temperature change. Expected to be minor.
Lake Installation		
	Lake Mixing	Varies with actual temperature change. Expected to be minor.
	Re-Oxygenation	None expected.

5.3.2.3 Impact Reduction.

Purchasing lost power is an option with costs identified within table 16. Another possibility is construction of an alternative method for powerplant cooling. Based on analysis at similar sites, the cost of implementing this is expected to be substantial. The extremely high construction cost of an option to provide powerplant cooling and the time duration make any alternate cooling method infeasible for this evaluation. Waiver of the NPDES temperature discharge requirement is not within the scope or authority of this analysis.

5.3.3 Downstream Water Users

Downstream water uses below the Garrison Dam include three municipal water supplies, an oil refinery, and several irrigation intakes. The cities of Washburn, Bismarck, Mandan and Ft. Yates use the Missouri River as a source of raw water.

5.3.3.1 Impact Summary.

Impacts that differ significantly from existing conditions for any of the alternatives are not anticipated. Impacts may occur as a result of changes in Missouri River water temperature or water levels. Since the flow levels are within the normal operating range of Missouri River Garrison flow releases, an impact to water users due to changing water levels is not anticipated. A nominal change in temperature and/or phytoplankton concentration would not result in an unacceptable challenge to properly treat the water.

5.3.3.2 Alternatives with Impacts.

Significant impacts that differ from existing conditions for any of the alternatives are not anticipated.

5.3.3.3 Impact Reduction.

Significant impacts that differ from existing conditions for any of the alternatives are not anticipated.

6. PREFERRED ALTERNATIVE

The selected alternative consists of a combination of modifying the Garrison daily flow cycle of releases and modifying the trash rack for 2 intakes. These alternatives were previously discussed within section 4.2.1 *Intake Trash Rack Modification* and section 4.3.2 *Modify Daily Flow Cycle*. Trash rack barrier installation on only two units was selected as optimal to provide flow capacity for all low flow releases, limit impacts to the Garrison Dam fish hatchery, limit impacts to the Garrison powerplant cooling, and limit temperature impacts to downstream water users.

NOTE:
Implementation of the trash rack modification may encounter unforeseen difficulties during construction that prevent successful installation of the barrier on one or both intakes. Removal of the trash rack sections, attachment of the barrier, and re-installation of the modified trash rack sections is not a simple task.

6.1 SELECTION PROCESS

These alternatives were selected during a joint meeting held on 4 May with attendees from numerous agencies including U.S. Army Corps of Engineers, North Dakota State Water Commission, North Dakota Game & Fish Department, U.S. Fish and Wildlife Service, North Dakota Department of Health, and the Garrison Dam National Fish Hatchery. Meeting notes are included in attachment 10.

This alternative was selected as superior for several reasons including:

1) Implementation in a short time frame (summer 2005) appears feasible
2) The selected alternatives minimize known impacts
3) The cost of implementing the selected alternative is reasonable
4) The selected alternative is technically feasible
5) The combination of the two alternatives provides greater potential benefit than either alternative individually

Other alternatives, such as the intake channel curtain and permanent intake channel barrier, may have a greater potential to increase the cold water fishery habitat volume. However, these alternatives also have numerous problems including a long implementation period that may not be completed in 2005, a high cost for implementation, and higher impacts to downstream users including the Garrison Dam National Fish Hatchery as previously discussed in section *5. Impacts and Constraints*.

6.2 SELECTED ALTERNATIVE DESCRIPTION

The selected alternative consists of modifying the Garrison daily flow cycle of releases to minimize mid-range flows and modifying the trash rack for units 2 and 3 to limit flow intake from depths below elevation 1720 for these two units. To the extent possible, all low flow releases will be through the two modified intakes. The maximum flow release of each unit will vary with pool level and additional head loss caused by the trash rack barrier but is estimated as 6,000 to 7,000 cfs per unit. High flow releases will be made using additional units as necessary. Normal Garrison Powerplant operation includes daily peaking operation for several hours. Components of the selected alternative are as follows:

Modify Daily Flow Cycle:
Results for the May monthly reservoir studies prepared by RCC show that for the summer of 2005, mean daily releases from Garrison are projected as 15,500 cfs (Table 1). The previous daily flow pattern at Garrison allowed significant operating time in the mid-level flow range between 12,000 and 18,000 cfs. A new suggested peaking pattern was developed by RCC that results in 15,500 cfs mean daily flow but eliminates the mid-level flow range. Operation is either near the minimum flow of 12,000 cfs or at the higher peak flow of 24,300 cfs. The peaking pattern includes a single block of the higher release, most likely in the afternoon to meet a typical late summer load demand. The developed peaking pattern is illustrated in tabular form in Plate 6. A figure was developed to compare the historic 2004 daily peaking pattern with the proposed revision and is also illustrated in Plate 6. Notes on implementation are as follows:

- Normal operation of the Garrison powerplant includes some hourly fluctuation by WAPA to meet power demands. A constant 12,000 cfs release will not occur.
- During the operation period, some unit downtime should be expected. Continued operation of unit 2 and 3 for the entire period from mid July to late September to meet all low flows will probably not occur.

Intake Trash Rack Modification:
The power tunnels are screened at the upstream end of the water passage by trash racks. These trash racks prevent large objects from entering the penstock and causing serious damage to features such as the wicket gates and turbine. Each of the 5 penstocks has two intake passages for a total of 10 intakes. The trash rack for each of the 10 intakes consists of 7 separate frame sections that are each 14 feet 6 inches high and 20 feet 8 inches wide. The trash rack fits into the trash rack slots at the front of the intake passage piers. A hook for each rack is fixed to the top of the frame. A lifting beam and mobile crane is used to raise and lower each trash rack section. Plate 2 illustrates the intake geometry.

The trash rack modification requires removal of the existing trash racks, attachment of the blocking barrier, and installation of the modified trash racks. Due to concerns with hydraulic flow streamlines, head loss, and developed forces, the maximum blocking elevation was limited. Above elevation 1715, the efficiency of the intake passage is severely reduced due to the constriction through the intake and the additional bend losses that occur. Based on the performed calculations, the maximum blocking elevation is 1720 ft msl.

The trash rack for each of the separate frame sections (14 feet 6 inches high and 20 feet 8 inches wide) includes 3-1/2" x ¾" bars spaced at 6-3/8" span 4'-10" to either an 18 I 70 beam or 18 C 42.7. Within the frame, the 18 C 42.7 supports the bars at the top and bottom of the trash rack, and the 18 I 70 at 4'-10" spacing support the bars in between.

The proposed barrier consists of 4'x8' sheets of ¾ " marine grade plywood. For each trash rack section, installation of the sheets will be from elevation 1672 to elevation 1720. The sheets will be installed vertically. Attachment will also include 2"x6" planks to provide additional stiffness and resistance for bolt attachment. Each plywood sheet will be attached on the upstream side of the trash rack grate.

Hydraulic and structural calculations related to the trash rack forces are illustrated in attachment 6. Computations were performed to evaluate the maximum force on the trash rack for normal conditions and load rejection conditions. A load rejection will cause a pressure wave to travel within the conduit from the power plant upstream to the intake structure and trash rack barrier. Computations were performed to consider the magnitude of the pressure wave during barrier attachment design. In addition, computations were also performed to evaluate the possible vibration frequency within the trash rack struts due to the increased flow velocity through the remaining open area.

Refer to attachment 11 for the limited detail plans that were developed to illustrate trash rack modification. Additional notes regarding trash rack installation are as follows:

- Trash rack barrier installation is not watertight. Some leakage will occur.
- A small slot is required at the bottom of the installation to limit silt accumulation during operation.
- Trash rack barrier installation is temporary and will be removed in the fall following lake turnover. At this time, cold water habitat volume is no longer impacted by the trash rack barrier.

- If obstacles are encountered during the trash rack barrier installation process it may not be possible to complete installation. Rather than compromise Garrison project integrity, the operation process will be halted.
- The intake modification was selected for units 2 and 3. Units 4 and 5, which supply cold water to the fish hatchery, were not considered. Construction issues may require consideration for barrier installation on unit 1 as a replacement for either unit 2 or unit 3.
- Computations determined that a destructive vibration force could occur through the trash rack struts at high velocity. For this reason, if the bottom trash rack section is not successfully removed, it will not be possible to install barriers on the upper sections and leave the bottom section non-altered.

6.2.1 Selected Alternative Cold Water Habitat Volume Impact

The impact on cold water habitat may be estimated from the daily flow release volume. The modification of the daily flow cycle will eliminate the mid-range flow releases that were not high enough to draw warmer water from the upper pool levels. Trash rack modification of two intakes will allow all low releases in the new daily flow cycle (10,000 cfs), to be made through the two modified units. Regarding impact, it is important to note that:

- The selected alternative will have minimal impact until the thermocline zone nears the elevation of the top of the trash rack barrier of 1720 ft msl.
- Impact is dependent upon unpredictable natural fluctuations as illustrated by the lake temperature difference in 2003 and 2004.
- Project alternative impacts are quantified using temperature. The potential impact on dissolved oxygen levels is not estimated. Preserving colder water does not necessarily mean coldwater habitat will be impacted. Coldwater habitat is not supported unless water temperatures are $\leq 15^oC$ and dissolved oxygen levels are $\geq$ 5 mg/l.

The coldwater habitat volume impact for each impact is:

Modify Daily Flow Cycle:

Referring to Plate 6, the positive benefit of this alternative may be viewed as the difference between the 2005 and 2004 plotted values. Cold water habitat volume is conserved when the mid flow range is reduced or eliminated during daily operation. Note that the benefit will be less this year since the average daily flow has decreased from the 18,000 cfs employed in 2004 to 15,500 cfs for 2005. Based on Plate 6, it appears that about 3,000 to 5,000 cfs falls within this range for a duration of about 6 to 12 hours. Using these values, the daily volume that could be impacted varies from 1,500 acre-feet to 5,000 acre-feet.

Intake Trash Rack Modification:

With modification of two intakes, all low releases could be made through the modified intakes. Using a low flow rate of 12,000 cfs, the release volume is 24,000 acre-feet per day. Note that operation without the modified intake at this flow rate is 100% cold temperature water. Actual impact will depend on the lake temperature elevations compared to the modified trash rack intake elevation of 1720 ft msl, performance of the modified structure during high flow releases, percent of time that the modified intakes are used for flow releases, and other unknowns such as the flow distribution to the modified intake with respect to lake temperature zones.

Combined Impact:

The combined impact of both alternatives is projected as 65% to 75% of the total release volume. Since the average daily release volume is currently estimated as 15,500 cfs or 31,000 ac-ft per day, the maximum impact is estimated as 20,000 - 23,000 acre-feet per day and about 600,000 – 660,000 acre-ft per month

6.2.2 Selected Alternative Impact Summary

Impacts will occur as a result of alternative implementation. Impacts of the selected alternative are summarized in table 19. Analysis of impacts must also recognize other changing conditions. For example, due to declining lake levels, warmer water temperatures are likely to be experienced by the Garrison Dam fish hatchery during high flow releases regardless of alternative implementation.

Table 19
Potential Impacts of the Selected Alternative

Potential Impacted Element	Primary Cause\Effect of Impact
Lake Sakakawea Cold Water Habitat Volume	Maximum impact is estimated to vary from 65% - 75% of release volume per day of implementation based on temperature – 20,000 to 23,000 acre-ft per day and 600,000 to 660,000 acre-ft per month. DO levels are not addressed.
Garrison Power Plant Cooling Water	Since intakes for units 1, 4, and 5 will not be affected, minimal impact is expected. Some impact will occur during high flow releases as the cooling water from the modified trash rack intakes must be used.
Garrison Power Plant Efficiency Losses	Modification of the trash rack will cause an additional head loss when operating units 2 and 3. The impact is estimated as about 1 – 2 % lost power. Dollar value impact is dependent on replacement power cost.
Downstream Coldwater Fish Hatchery	Since units 4 and 5 will not be altered, the selected plan should have minimal impact on temperature of water in penstocks 4 and 5 and water quality impacts to the hatchery should be minimal.
Downstream Tailwater Coldwater Fishery and River Fishery	The selected alternative is expected to increase the temperature of flow releases. Increasing temperature of release water raises downstream Missouri River temperature and impacts species environment.
Downstream Power Plants Cooling Water	The selected alternative is expected to increase the temperature of flow releases. Higher Missouri River temperature impacts power plant cooling capability and generation efficiency. Dollar value impact is dependent on efficiency loss (which will vary depending on release temperature and other factors such as ambient air temperature) and replacement power cost.
Downstream Channel and Water Users	Release flow levels are within normal operating conditions. No significant impact is anticipated.
Downstream Municipal Water Users	Release flow levels are within normal operating conditions. No significant impact is anticipated.
Threatened and Endangered Species	No significant impact is anticipated.

6.2.3 Cumulative Effects

The Council on Environmental Quality (CEQ) Regulations for Implementing NEPA defines a cumulative impact as "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency or person undertakes such other actions." The CEQ Regulations further state that "cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time."

The proposed alternative action to maintain cold water habitat in Lake Sakakawea is in itself a minor activity that will have insignificant to beneficial downstream effects (esp. water temperature) and significant beneficial effects to coldwater habitat in the reservoir. Other activities that similarly effect the downstream environment within the impacted area are the normal operations of the dam, and downstream power plants that release heated effluent into the river. The current conditions and relation of the operation of Garrison Dam to the proposed alternatives has already been discussed, demonstrating that beneficial impacts to what remains of the indigenous aquatic community would occur, with little affect on the managed coldwater fishery. The powerplant effluent would also be considered ameliorating in their effect on water temperatures in the river with relation to the indigenous aquatic community (similar to tributary confluences that were also previously discussed), especially when considered cumulatively with the warmer water releases. Because there are controls in place that reduce the potential effect of the effluent on the river with regard to temperature and other parameters (NPDES), the additive effects would not reach a temperature level beyond natural levels. In addition, it is unlikely that there would be negative cumulative effects to the coldwater fishery as the fishery is limited to the first twenty or so miles below the Dam. This is upstream of the first confluence (Knife River) and the first power plant that provide warmer waters to the river. The water temperature in Lake Oahe is not anticipated to be impacted via the cumulative factors by the time the river reaches Bismarck, near the Oahe headwaters, as the river temperatures have met ambient air temperatures at that point.

6.2.4 Selected Alternative Construction Cost

The modify daily flow cycle does not have a construction cost. Construction costs for the trash rack barrier installation are estimates based on an assumed time length and material cost. Crane rental cost is a significant portion of the total cost. Actual installation time could vary significantly. Total material and construction costs are estimated as between $40,000 and $50,000 for the modification of two intakes. Refer to attachment 11 for a breakdown of estimated costs.

6.3 FEDERAL OR STATE PERMITS

The implementation of the selected alternative is not anticipated to require any permits. The only construction activity is the installation of the plywood barrier.

6.4 SELECTED ALTERNATIVE IMPLEMENTATION

The implementation process for the selected alternative is as follows:

6.4.1 Monitoring

Monitoring will be performed following construction to evaluate performance during 2005. An actual monitoring plan detailing equipment and location has not been determined but will include temperature data collection.

6.4.2 Modify Daily Flow Cycle

Implementation of the flow release modification alternative is the responsibility of RCC. Omaha District has coordinated with RCC regarding implementation. This alternative will not require any construction. Current status is that RCC has coordinated this option with Western Area Power Administration (WAPA). The daily flow cycle has been modified in accordance with the flow release schedule illustrated on Plate 6. Initial implementation of the modified daily flow cycle occurred in May, 2005, prior to the majority of the least tern and piping plover nesting season. Small adjustments to the pattern may occur during the next few weeks.

6.4.3 Intake Trash Rack Modification

Current projections for implementation are as follows:

Unit 3 – Completion 2 July   Unit 2 – Completion 16 July

Implementation of the trash rack modification alternative is shown in Table 20.

Table 20
Implementation of Trash Rack Modification

Item	Date	Notes
Plans and specifications	27 May 2005	Complete plans and specs package that illustrate connections and installation of trash rack barrier.
Mobile Crane Rental Purchase Order	27 May 2005	Complete purchase order for rental of mobile crane required for trash rack removal. Crane required on-site from 27 June to 1 July.
Materials Procurement	20 June – 8 July	Procure ¾” marine plywood and attachment bolts. Deliver to Garrison and inspect. Assemble attachment tools and required removal equipment at intake structure.
Prototype testing (unit 3) prior to modification	26 June	Perform prototype testing and record observations for a range of load conditions. Data will be used to compare before and after modification.
Trash rack removal – Unit 3. NOTE: Removal will not be started until Unit 2 commissioning runs are complete to avoid impact to powerplant operation.	11 – 12 July	Use mobile crane to remove trash rack units, inspect trash rack base with ROV camera during removal. Check bottom for debris and sediment. Anticipate 2 days. NOTE: Dive contract will not be utilized unless damage occurs and underwater repair is required. Outage of unit 3 required during installation period. Close adjacent passage gates on unit 2 and 4 (unit operation still possible but only thru one passage).
Inspect trash rack	12 – 14 July	Inspect welds and sections for damage, deformation, etc. Repair as necessary.
Install barrier	12 – 14 July	Install ¾” marine grade plywood from bottom to elevation 1720. NOTE: If camera inspection or removal determines blockage issues with gate bottom, barrier installation may not be feasible.
Replace trash rack	14 - 15 July	Replace all trash rack sections. Perform ROV camera inspection of base trash racks after installation to verify placement.
With barrier installed prototype testing (unit 3)	15 - 16 July	Perform prototype testing and observe. Slowly increase load to check for any unanticipated flow issues. Compare to pre-installation test results.
Prototype testing (unit 2) prior to modification	15 July	Perform prototype testing and record observations for a range of load conditions. Data will be used to compare before and after modification.
Unit 2 – Repeat Unit 3 Installation Sequence	18 July – 22 July	Repeat sequence used for unit 3 on unit 2. Outage of unit 2 required during installation period.
Unit 2 and 3 – Remove Barriers	Approx. Oct.	Remove the barriers from unit 2 and 3 and inspect. Removal will occur in late September or early October following lake turnover.

Note: Construction difficulties may require adjustment of the proposed schedule.

A major requirement for implementation is crane availability that meets lifting and intake structure access limits. The following points summarize crane requirements for the trash rack alternative:

1. Width of access bridge to Intake Structure: 14' 0"
2. Clearance width of the overhead doors to the Intake Structure: 15' 6"
3. Clearance height of the overhead doors to the Intake Structure: 22' 6"
4. Width of the work deck on the north side of the Intake Structure: 29'
5. Elevation of the work deck on the north side of the Intake Structure: 1865 msl
6. Elevation of the gate slot at the bottom of the Intake Structure: 1672 msl
7. Work to be conducted on Unit 3: Week of June 27, 2005
8. Work to be conducted on Unit 2: Week of July 11, 2005
9. Scope of work: Remove the existing trash racks from the trash rack slots for each of two units and reinstall the trash racks following the modifications to be accomplished by the Corps. There are two intakes for each unit with seven trash racks per intake. The trash racks are to be removed using the Corps lifting beam which connects directly to the load block on the crane. Each trash rack is approximately 15' tall, 20' 6" wide, and 2' 6" deep and weigh approximately 30,000 pounds each including the weight of the lifting beam.

7. LIST OF AGENCIES AND PERSONS CONSULTED

Consulted agencies include the following:
Garrison Dam National Fish Hatchery.
North Dakota Department of Health, Bismarck ND.
North Dakota Game & Fish Department, Bismarck ND.
North Dakota State Water Commission, Bismarck ND.
U.S. Army Corps of Engineers, Garrison ND Project Office.
U.S. Army Corps of Engineers, Bismarck ND Regulatory Office.
U.S. Army Corps of Engineers, Hydroelectric Design Center, Portland, OR.
U.S. Fish and Wildlife Service, Bismarck ND.

8. COMPLIANCE WITH ENVIRONMENTAL STATUTES

American Indian Religious Freedom Act (AIRFA) of 1978, 42 U.S.C. 1996. *In compliance.*
AIRFA protects the rights of Native Americans to exercise their traditional religions by ensuring access to sites, use and possession of sacred objects, and the freedom to worship through ceremonials and traditional rites. This project would not adversely affect the protections offered by this Act. Access to sacred sites by Tribal members would not be affected.

Bald Eagle Protection Act, 16 U.S.C. Sec. 668, 668 note, 668a-668d. *In compliance.*
The Endangered Species Act (ESA) contains requirements on Corps projects concerning bald eagles. See Endangered Species Act.

Clean Air Act, as amended, 42 U.S.C. 1857h-7, et seq. *In compliance*.
The purpose of this Act is to protect public health and welfare by the control of air pollution at its source, and to set forth primary and secondary National Ambient Air Quality Standards to establish criteria for States to attain, or maintain. Some temporary emission releases may occur during construction activities; however, air quality is not expected to be impacted to any measurable degree.

Clean Water Act, as amended, (Federal Water Pollution Control Act) 33 U.S.C. 1251, et seq. *In compliance*.
The objective of this Act is to restore and maintain the chemical, physical and biological integrity of the Nation's waters (33 U.S.C. 1251). Section 404 requires authorization to place dredged or fill material into water bodies or wetlands. If a section 404 authorization is required, a section 401 water quality certification from the state in which the discharge originates is also needed. The proposed project

consists only of work on the dam and will not cause placement of fill materials into the lake. Therefore it ***will not*** require a section 404 authorization or section 401 water quality certification. _A National Pollution Discharge Elimination System permit ***will not*** be required from the State of North Dakota for this activity. Because the activity will be taking place on the dam, erosion and stormwater discharges during and after construction will not occur.

Comprehensive Environmental Response, Compensation, and Liability Act of 1980. *Not applicable*. Typically CERCLA is triggered by (1) the release or substantial threat of a release of a hazardous substance into the environment; or (2) the release or substantial threat of a release of any pollutant or contaminant into the environment which presents an imminent threat to the public health and welfare. To the extent such knowledge is available, 40 CFR Part 373 requires notification of CERCLA hazardous substances in a land transfer. This project does not involve any real estate transactions.

Endangered Species Act, as amended, 16 U.S.C. 1531, et seq. *In compliance*. Section 7 (16 U.S.C. 1536) states that all Federal departments and agencies shall, in consultation with and with the assistance of the Secretary of the Interior, insure that any actions authorized, funded, or carried out by them do not jeopardize the continued existence of any threatened or endangered (T&E) species, or result in the destruction or adverse modification of habitat of such species which is determined by the Secretary to be critical. According to the U.S. Fish and Wildlife Service (USFWS) North Dakota Field Office home page, the following threatened and endangered species, or their critical habitats occur within McLean and Mercer Counties, North Dakota:

- Pallid Sturgeon (E)
- Interior Least Tern (E)
- Piping Plover (T)
- Designated Piping Plover Critical Habitat
- Bald Eagle (T)
- Whooping Crane (E)
- Gray Wolf (T)
- Black-Footed Ferret (E)

A biological assessment was prepared based on the above species list, except the gray wolf and black-footed ferret, which are not found in habitats associated with the project site. A letter concurring that this project would have "no effect" or is "not likely to adversely affect" threatened and endangered species is expected, but still needed from the USFWS prior to proceeding.

Farmland Protection Policy Act (Subtitle I of Title XV of the Agriculture and Food Act of 1981), effective August 6, 1984. *Not Applicable.* This Act instructs the Department of Agriculture, in cooperation with other departments, agencies, independent commissions and other units of the Federal government, to develop criteria for identifying the effects of Federal programs on the conversion of farmland to nonagricultural uses. This project will not affect agricultural lands.

Federal Water Project Recreation Act, as amended, 16 U.S.C. 460-1(12), et seq. *In Compliance.* The Act establishes the policy that consideration be given to the opportunities for outdoor recreation and fish and wildlife enhancement in the investigating and planning of any Federal navigation, flood control, reclamation, hydroelectric or multi-purpose water resource project, whenever any such project can reasonably serve either or both purposes consistently. This project is meant to protect the viability of the recreational fishery in Lake Sakakawea.

Fish and Wildlife Coordination Act, as amended, 16 U.S.C. 661, et seq. *In compliance*. The FWCA requires governmental agencies, including the Corps, to coordinate activities so that adverse effects on fish and wildlife will be minimized when water bodies are proposed for modification. Close coordination with the USFWS and the North Dakota Game and Fish is being maintained in the planning of this project. Letters from the agencies mentioned above are expected to concur with the project activities.

Land and Water Conservation Fund Act (LWCFA), as amended, 16 U.S.C. 4601-4601-11, et seq.
Not applicable. Planning for recreation development at Corps projects is coordinated with the appropriate states so that the plans are consistent with public needs as identified in the State Comprehensive Outdoor Recreation Plan (SCORP). The Corps must coordinate with the National Park Service (NPS) to insure that no property acquired or developed with assistance from this Act will be converted to other than outdoor recreation uses. If conversion is necessary, approval of NPS is required, and plans are developed to relocate or re-create affected recreational opportunities. No lands or properties involved in the proposed project were acquired or developed with LWCFA funds.

National Environmental Policy Act (NEPA), as amended, 42 U.S.C. 4321, et seq. *In compliance.* This environmental assessment (EA) and finding of no significant impact (FONSI) have been prepared for the proposed action. An environmental impact statement is not required.

National Historic Preservation Act, as amended, 16 U.S.C. 470a, et seq. *In compliance.*

Federal agencies having direct or indirect jurisdiction over a proposed Federal or federally assisted undertaking shall take into account the effect of the undertaking on any district, site, building, structure, or object that is included in or eligible for inclusion in the National Register of Historic Places. No ground disturbance, historic structure alteration or shoreline erosion will occur as a result of this alternative. The project therefore involves No Historic Properties Subject to Effect. The North Dakota State Historic Preservation Office reviewed the information, and concurred with our determination.

Noise Control Act of 1972, 42 U.S.C. Sec. 4901 to 4918. *In compliance.* This Act establishes a national policy to promote an environment for all Americans free from noise that jeopardizes their health and welfare. Federal agencies are required to limit noise emissions to within compliance levels. Appropriate measures will be taken to keep the noise levels associated with this project within the compliance levels.

North American Wetlands Conservation Act, 16 U.S. C. Sec. 4401 et. seq. *Not applicable.* This Act establishes the North American Wetlands Conservation Council (16 U.S.C.4403) (NAWCC) to recommend wetlands conservation projects to the Migratory Bird Conservation Commission (MBCC). Section 9 of the Act (16 U.S.C. 4408) addresses the restoration, management, and protection of wetlands and habitat for migratory birds on Federal lands. Federal agencies acquiring, managing, or disposing of Federal lands and waters are to cooperate with the Fish and Wildlife Service to restore, protect, and enhance wetland ecosystems and other habitats for migratory birds, fish and wildlife on their lands, to the extent consistent with their missions and statutory authorities. There will be no disposal of land with this rehabilitation project.

Section 10 of the Rivers and Harbors Act of 1899 (33 U.S.C. 403) *In compliance.*
This law prohibits the unauthorized obstruction or alteration of any navigable water of the United States. This section provides that the construction of any structure in or over any navigable water of the United States, or the accomplishment of any other work affecting the course, location, condition, or physical capacity of such waters is unlawful unless the work has been recommended by the Chief of Engineers and authorized by the Secretary of the Army. The Secretary's approval authority has since been delegated to the Chief of Engineers. Because the Corps of Engineers is doing this project, no authorization is required because the law specifically exempts the Corps of Engineers from regulation under Section 10.

Watershed Protection and Flood Prevention Act, 16 U.S.C. 1101, et seq. *Not applicable*. This Act authorizes the Secretary of Agriculture to cooperate with states and other public agencies in works for flood prevention and soil conservation, as well as the conservation, development, utilization, and disposal of water. This act imposes no requirements on Corps Civil Works projects.

Wild and Scenic Rivers Act, as amended, 16 U.S.C. 1271, et seq. *Not applicable*. This act establishes that certain rivers of the Nation, with their immediate environments, possess outstandingly remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural, or other similar values, shall be preserved in free-flowing condition, and that they and their immediate environments shall be protected for the benefit and enjoyment of present and future generations. Lake Sakakawea is not designated as a wild or scenic river, nor is it, or any nearby tributaries, on the National Inventory of Rivers potentially eligible for inclusion in the wild and scenic rivers system.

Environmental Justice (E.O. 12898). *In compliance*. Federal agencies shall make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations in the United States. The project does not impact minority or low-income populations.

Floodplain Management (E.O. 11988). *In compliance*. Section 1 requires each agency to provide leadership and take action to reduce the risk of flood loss, to minimize the impact of floods on human safety, health and welfare, and to restore and preserve the natural and beneficial values served by floodplains in carrying out its responsibilities for (1) acquiring, managing, and disposing of Federal lands and facilities; (2) providing Federally undertaken, financed, or assisted construction and improvements; and (3) conducting Federal activities and programs affecting land use, including but not limited to water and related land resources planning, regulating, and licensing activities. This project will not affect the flood holding capacity or flood surface profiles of any stream.

Protection of Wetlands (E.O. 11990). *In compliance*. Federal agencies shall take action to minimize the destruction, loss or degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands in carrying out the agencies responsibilities. Each agency, to the extent permitted by law, shall avoid undertaking or providing assistance for new construction located in wetlands unless the head of the agency finds (1) that there is no practicable alternative to such construction, and (2) that the proposed action includes all practicable measures to minimize harm to wetlands, which may result from such use. In making this finding the head of the agency may take into account economic, environmental and other pertinent factors. Each agency shall also provide opportunity for early public review of any plans or proposals for new construction in wetlands. ***Any wetlands located in the vicinity of possible mobilization sites, etc. will be avoided. A Section 404 Permit will not be needed for implementing this project (see Clean Water Act above).***

CEQ Memorandum, August 10, 1980, Interagency Consultation to Avoid or Mitigate Adverse Effects on Rivers in the Nationwide Inventory. ***In Compliance***. This memorandum states that each Federal agency shall take care to avoid or mitigate adverse effects on rivers identified in the Nationwide Inventory (FR 1980). No portion of Lake Sakakawea is listed on the Nationwide Rivers Inventory, however, the Garrison Reach from Garrison Dam to the Knife River, and the segment within the Knife River Indian Villages National Historic Site are in the inventory. The reasoning behind the listing is due to the presence of Federally listed species in this reach. This project should be beneficial to native river species within this reach.

9. REFERENCES

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Garrison Dam and Intake Channel

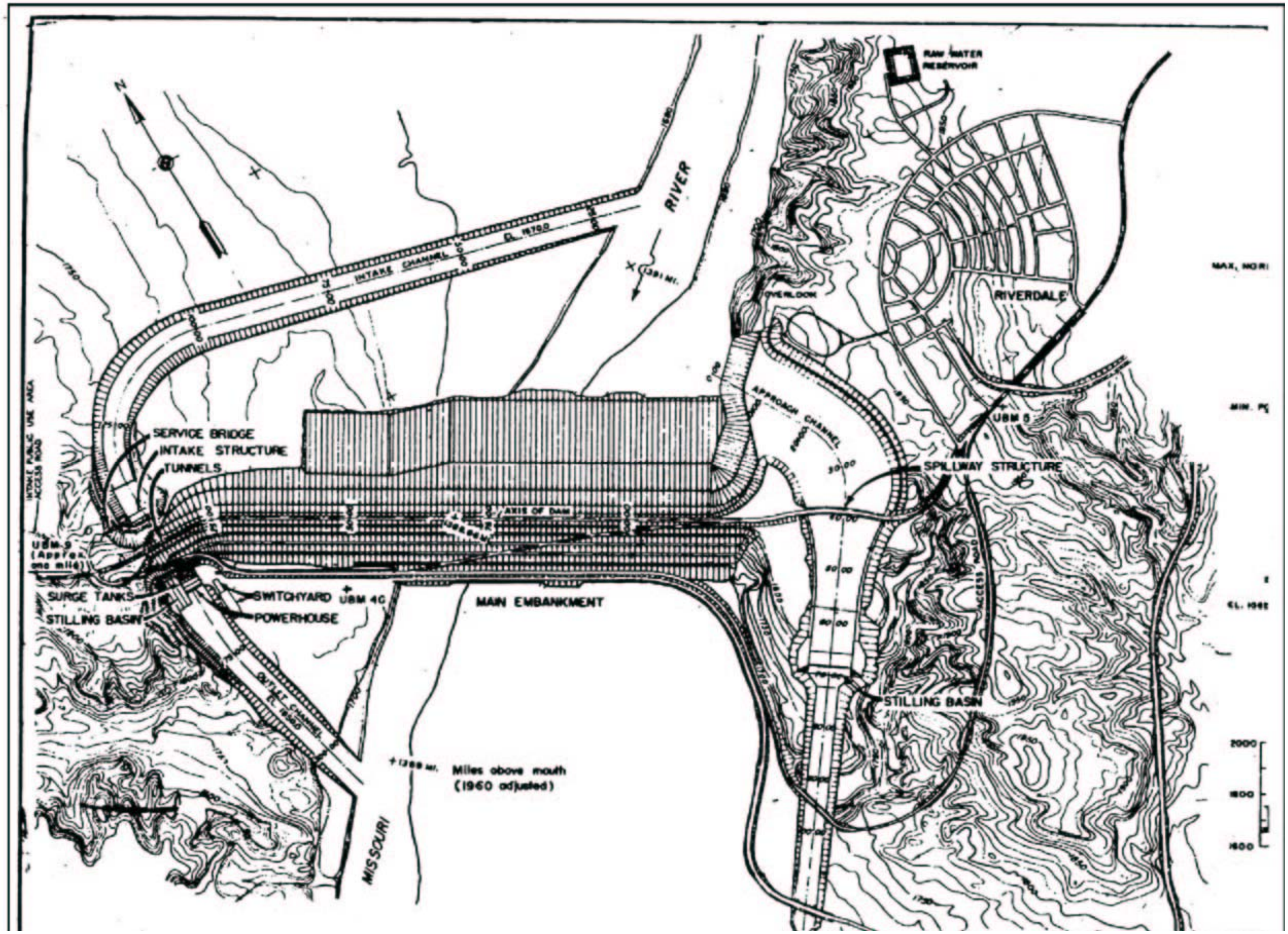
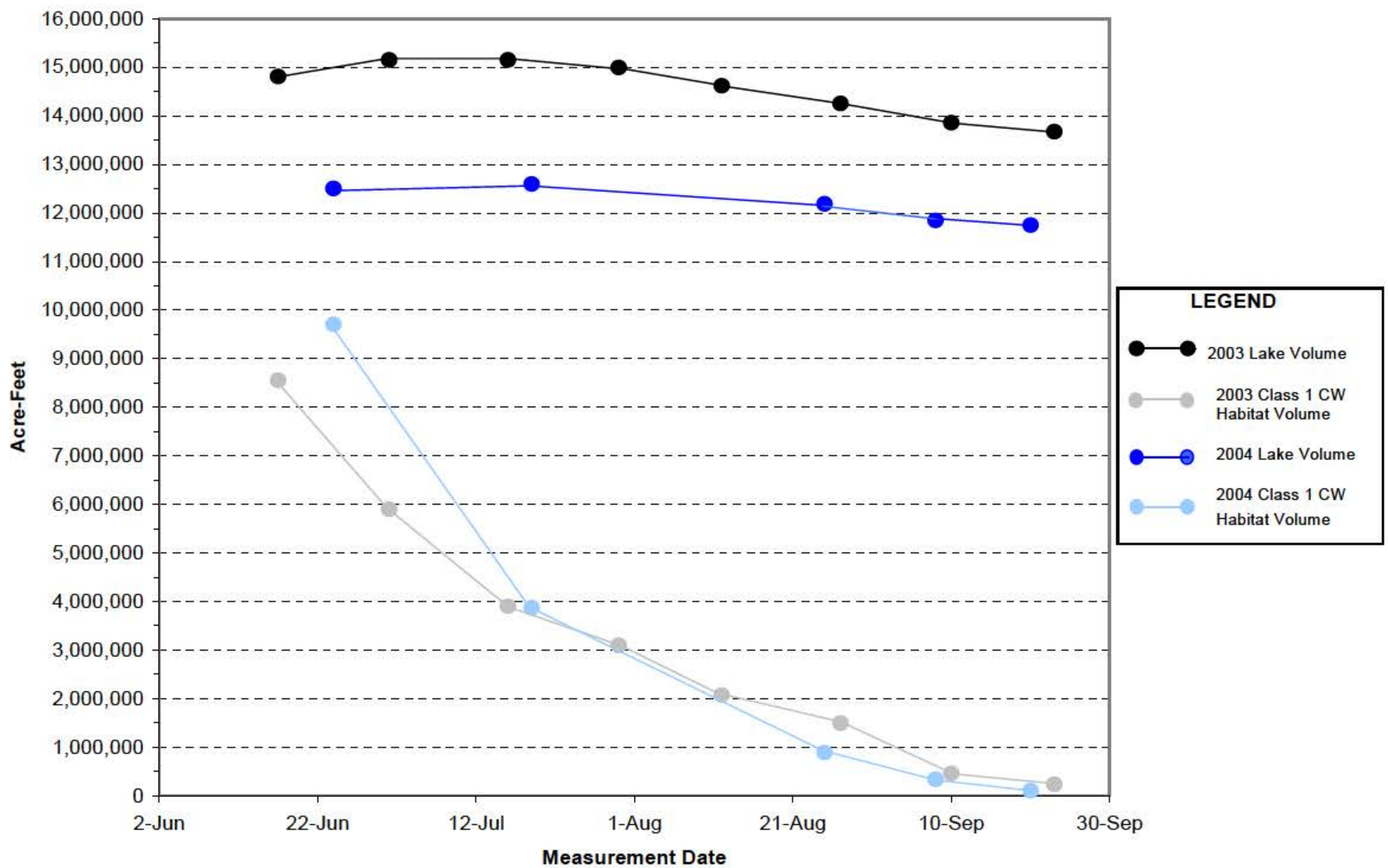


Plate 1

Garrison Dam Intake Structure

(Figure Removed)

Lake Volumes and Optimal Cold Water Habitat Estimated in Lake Sakakawea during 2003 and 2004



Missouri River Dam Release vs. Temperature Comparison, Example Data from August 2004

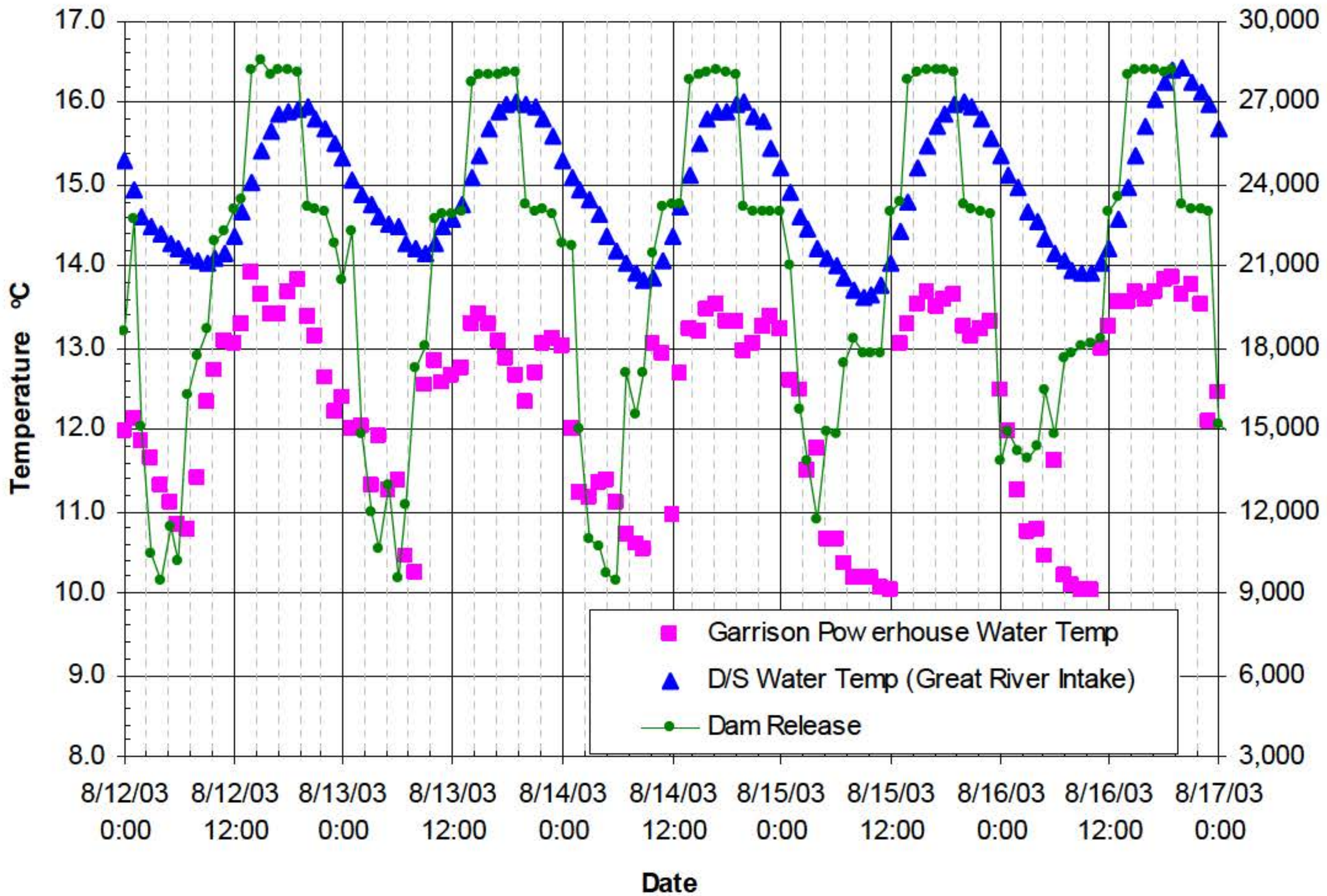


Plate 4

Lake Sakakawea Walleye Natural and Total Mortality Rate

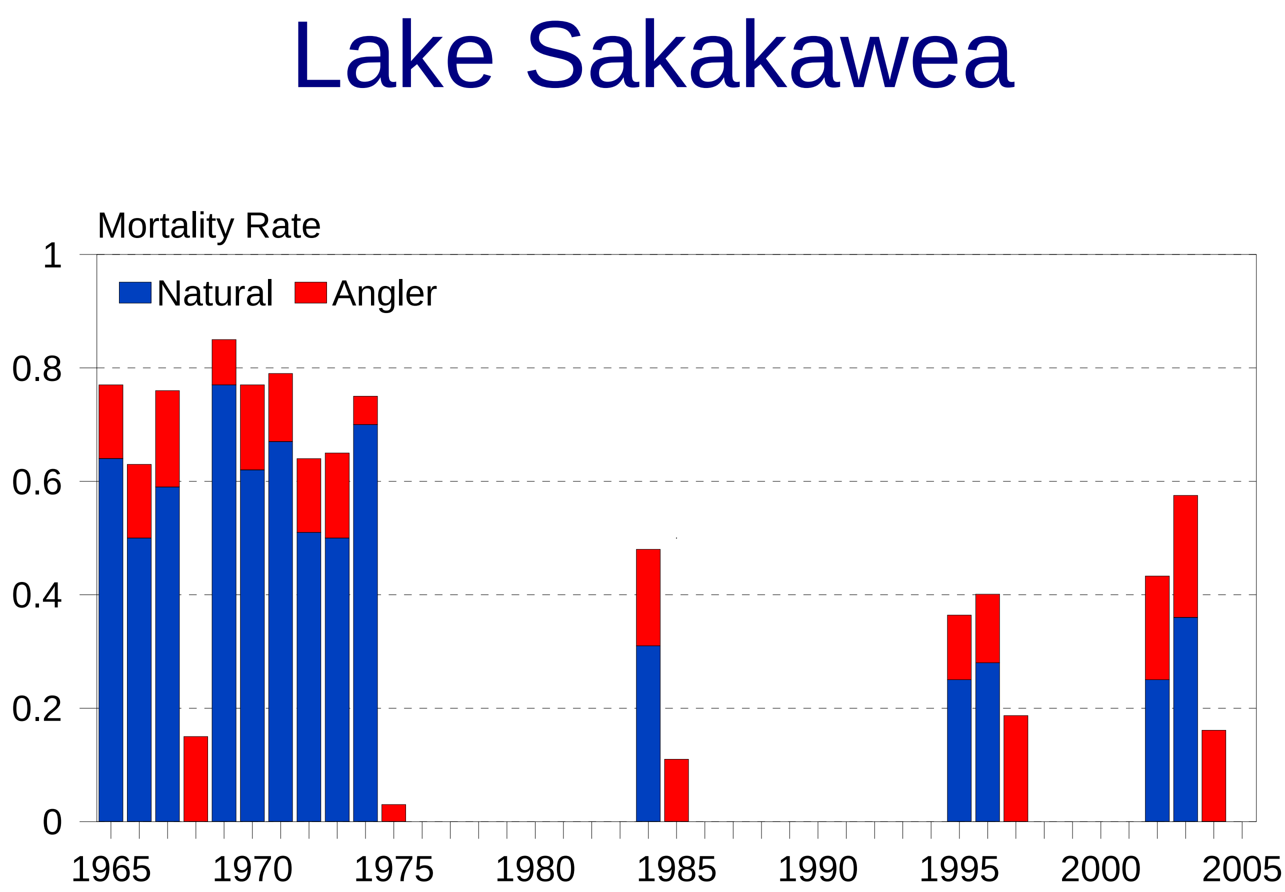


Plate 5

Garrison Dam Peaking Pattern Evaluation

Hour	1	2	3	4	5	6	7	8	9	10	11	12	
Kcfs	12	12	12	12	12	12	12	12	12	12	12	12	Daily Avg.
Mw	121	121	121	121	121	121	121	121	121	121	121	121	15.5 Kcfs
Hour	13	14	15	16	17	18	19	20	21	22	23	24	Mwh=3772
Kcfs	12	24.3	24.3	24.3	24.3	24.3	24.3	24.3	12	12	12	12	
Mw	121	245	245	245	245	245	245	245	121	121	121	121	

/MISSOURI/GARR/RELEASE/01JUN2004/1HOUR/2005 PATTERN/

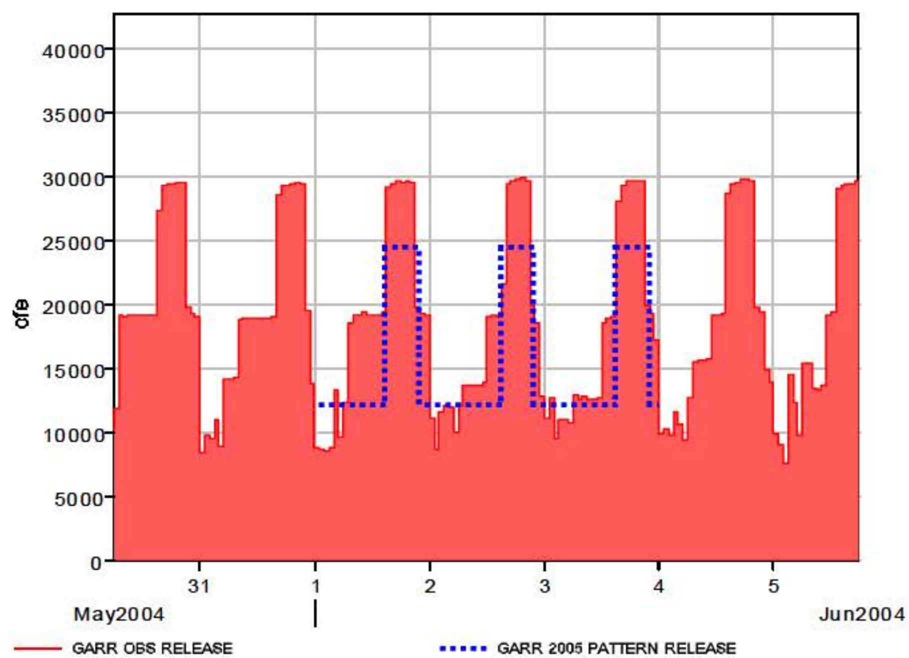


Plate 6